GUIDANCE MANUAL

FOR LANDFILL SITES

RECEIVING MUNICIPAL WASTE

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PREFACE

Everyone involved with the management of municipal waste should have a clear understanding of the place that landfilling occupies in the practice of waste management in the Province of Ontario. It is essential to understand the procedures and actions that need to be taken to achieve the objectives of provincial regulations and policies. This document is intended to provide a clear description of the process by which **landfill sites receiving municipal waste** are designed, developed, operated, and closed.

Clear understanding and consistent application of requirements for landfill sites can result in better design and operation as well as facilitating timely development of new sites. Requirements are stipulated by Acts, regulations, Ministry of Environment and Energy (MOEE) Policies, or they can be design/operational features normally required by the MOEE for Certificate of Approval issuance. These types of requirements are clearly noted as such within the Guidance Manual. The document also includes discussion of some of the design and operational features, dictated by site conditions, that are necessary in order to achieve a good facility.

The Guidance Manual is applicable to landfill sites in Ontario receiving municipal waste. **Municipal waste** includes domestic waste and non-hazardous solid wastes from industrial, commercial and institutional sectors. Landfill sites, designed and approved to accept municipal waste, are not permitted to accept hazardous or liquid industrial waste as defined under Ontario Regulation 347.

The Guidance Manual is intended for use or benefit of the owners and operators of landfills (both publicly and privately owned sites), regulatory authorities, consultants and members of the public concerned with landfilling practice in their community.

The focus of the document is on the design, development, operation, closure and post-closure care of landfill sites. An overview of planning and approval steps for landfill sites is provided to assist the readers in gaining an understanding of the beginning to end life-cycle of landfill sites. **The Guidance Manual is not intended as a 'design' document, but rather provides guidance on provincial requirements and good waste management practices.**

Section 1, Introduction, of the Guidance Manual provides a general overview of landfilling in Ontario. It also provides insight into current environmental legislation, regulations and government policies pertaining to landfilling.

Section 2, Planning and Approvals, of the Guidance Manual outlines the landfill planning and approval processes required by the provisions of the Environmental Protection Act (EPA) and the Environmental Assessment Act (EAA). It provides an introduction to the planning process and a summary of the approval processes, which may be necessary, prior to

the issuance of a Certificate of Approval and the establishment of a landfill site. Section 2 also provides information on public participation and the expansion of existing sites.

Section 3, Principle Considerations in Landfill Design, provides design philosophy and principle considerations in designing landfill sites. This section includes discussions of hydrogeological investigations at landfill sites and the design criteria essential to the development of effective environmental controls given site-specific conditions. Section 3 also provides details on the technical documentation normally required to support an application for a Certificate of Approval. This section may be particularly useful to consultants and other professionals assisting proponents of landfill sites in meeting the requirements of the EPA.

Section 4, Site Development, Operations and Design Features, describes the regulatory requirements, policies and procedures for the design, development, operation and management of landfill sites. It provides information on the design features and operation of various engineered systems, including leachate control measures, ground water protection measures, landfill gas control measures and monitoring systems. It includes discussions of site preparation, waste disposal methods and recommended operational procedures. Each subsection within, commences with a rationale explaining the significance of a particular operational feature or requirement. Section 4 should be useful to all those wishing to better understand the activities that can take place within landfill sites, but it may be particularly helpful to landfill operators and to regulatory staff. Summary tables, listing typical measures and practices for landfill sites, are also included.

Section 5, Closure of Landfill Sites, includes discussions of the regulatory requirements and procedures associated with the closure of landfill sites. The discussions emphasize the benefit in planning the site closure well in advance of the actual closure, and the advantages in utilizing a staged closure in order to prepare the landfill site for its intended end-use.

Appendix I contains a glossary of terms commonly used in the context of landfilling practices in Ontario. Appendix II lists relevant statutes of legislation, government regulations, current MOEE policy documents and other references relevant to landfills.

This Guidance Manual supersedes earlier MOEE guidance document on landfills entitled "Guidelines for the Establishment, Operation, Management, Maintenance and Closure of Landfilling Sites in Ontario". It, however, does not change or replace in any way, current legislation or MOEE policies on landfilling and waste management. It should also be understood that **landfill sites, at all times, must operate in compliance to their respective Certificates of Approval.**

GUIDANCE MANUAL FOR LANDFILL SITES RECEIVING MUNICIPAL WASTE

TABLE OF CONTENTS

APPENDICES

SECTION 1
INTRODUCTION

SECTION 2
PLANNING AND APPROVALS

Figure

SECTION 3
PRINCIPLE CONSIDERATIONS IN LANDFILL DESIGN

Tables

SECTION 4
SITE DEVELOPMENT, OPERATIONS AND DESIGN FEATURES

Figures

SECTION 5
CLOSURE OF LANDFILL SITES

SECTION 1

INTRODUCTION

1.1 INTRODUCTION

Prior to the introduction of the Environmental Protection Act (EPA) in 1971, open dumping of wastes in unregulated manner was common practice in parts of Ontario. The EPA is a result of the initiatives to control waste disposal and better protect the public and the environment undertaken by local health units, the Department of Energy and Resources Management and the Ontario Water Resources Commission (now the Ontario Ministry of Environment and Energy) in the 1960's. Landfilling of waste involves the systematic placement and covering of waste in a controlled environment to minimize the blowing away of debris, to control odours, to prevent spread of disease by insects, animals and birds, and most importantly to eliminate hazards to public health and safety and prevent contamination of the environment.

Landfilling is a key component of any waste management system serving communities across the Province of Ontario. As part of the Government policy on waste management for the Province, communities are required to vigorously pursue the options of implementing 3Rs programs (reduction, reuse and recycling of waste) to achieve diversion objective of at least 50 percent of waste from landfill sites by the year 2000. Despite the initiatives that are underway to reduce the amount of waste being disposed of in landfills, there will be a continuing need for carefully planned and well managed landfill sites. With the growth of communities and with industrial development associated with such growth, there is an increasing demand for new waste disposal facilities and more landfill capacity. Strong public involvement and the successful implementation of 3Rs programs should serve to extend the life span of new and existing landfill sites.

In order to maintain financial self sufficiency, landfill owners and operators are encouraged to manage their sites on the basis of full cost recovery, where the users and beneficiaries are expected to pay for all aspects of waste handling from collection through disposal. Landfill sites, based on full cost recovery can generate revenues needed to develop, operate, close-out and replace waste disposal facilities. Tipping fees charged for receiving and managing waste is one way by which waste generators and users of landfill sites contribute financially towards cost recovery. Currently, municipal property tax serves as another, albeit, indirect means of revenue for municipally owned site(s) in a community. The benefits derived by a community in working towards a "user pay" system where all waste generators would pay directly for landfill operation and replacement, need to be stressed by municipalities and other owners/operators of landfill sites.

Landfill sites that are properly located, designed and operated with adherence to sound engineering principles and good management practices, pose minimal risk to public health and the environment. Present technology provides us with the capability to understand and predict the performance of landfill sites in various environmental and geologic settings. This enables landfill designers to develop, install, and in some cases, retrofit appropriate safeguards and mitigative measures necessary to ensure safe performance. Current environmental legislation

in the Province provides the necessary legal framework for the planning, development, operation, maintenance, closure, and post-closure of landfill sites in order to ensure that the public and the environment are protected.

1.2 LEGISLATIVE FRAMEWORK FOR LANDFILL SITES

1.2.1 Environmental Legislation and Regulations

This subsection is intended to provide general information on the provisions of the main Acts of legislation in the regulation of landfilling practices in Ontario. Those requiring detailed legal text are advised to consult the relevant Acts and regulations.

a) The Environmental Protection Act (EPA)

The EPA is the primary legislation for the protection and conservation of the natural environment. Part V of the EPA provides a legislative framework for the establishment of waste management facilities. The establishment, operation, management, alteration, enlargement and/or extension of landfill sites in the Province require a Certificate of Approval under Part V, Section 27 of the EPA. In general, the provisions under the EPA require specific and detailed technical analysis of a specific site with the requirement that the proponent address the potential effects on the natural environment (air, land, and water), including transportation and noise aspects.

Section 30 of the EPA stipulates that a mandatory public hearing shall be held before the Environmental Assessment Board, prior to the issuance or denial of a Certificate of Approval for a landfill site, where such a site is intended to receive hazardous or liquid industrial waste or receive waste equivalent of domestic waste of 1,500 persons or more. It may be noted that approximately two-third of municipal waste landfill sites in Ontario currently fall under this category. A discretionary hearing, under Section 32 of the EPA, may be held for any landfill not falling under the mandatory hearing provision.

Under exceptional circumstances where there is a clearly demonstrated emergency situation, the MOEE may issue a Certificate of Approval, under Section 31 of the EPA, without requiring an Environmental Assessment Board hearing.

b) The Environmental Assessment Act (EAA)

The EAA is intended to provide for the "protection, conservation and wise management of the environment" through sound planning and informed decision making in the selection and establishment of major undertakings in the Province, including landfill sites. The planning requirements under the EAA are extensive and include evaluating a range of alternatives before selecting a preferred system or facility.

In regards to landfills, the EAA is applicable to landfill proposals that require mandatory hearing under Section 30 of the EPA. Further, any projects, at the discretion of the Minister of the Environment, can be designated to meet the provisions of the EAA.

Section 5 of the EAA requires a proponent, among other requirements to consider alternatives and seek approval for the alternative (site) that has the least effect on the environment. In the context of the EAA, the "environment" includes not only the natural environment, but "the social, economic and cultural conditions that influence the life of people or a community".

Section 6 of the EAA stipulates that a Certificate of Approval under Part V of the EPA will not be issued for a landfill site prior to the proponent submitting an environmental assessment and obtaining approval under the EAA for the site.

Under exceptional circumstances, exemption from the EAA may be granted by the Minister under Section 29 of the EAA.

c) The Ontario Water Resources Act (OWRA)

The purpose of the OWRA is for the protection and conservation of the surface and ground water resources in the Province.

Direct or indirect discharge of storm water and wastewater into drainage courses, sewers, water bodies and watercourses are regulated to minimize the impairment of water quality.

Surface drainage controls or detention works require approval under Section 53 of the OWRA. Generally, the on-site leachate collection and treatment systems require approval under Part V of the EPA, however, the process and facility subsequent to collection can require approval under Section 53 of the OWRA.

Provincial Water Quality Objectives have been established by the MOEE. It is a set of qualitative and numerical criteria designed to represent a desirable level of water quality in surface water resources. These water quality criteria are used in establishing controls for effluent discharge into receiving bodies of surface water.

d) Ontario Regulation 347

Regulation 347 (formerly Regulation 309) under the EPA is the primary regulation for controlling the handling, disposal and management of hazardous and non-hazardous wastes in the Province. Under the Regulation, wastes are classified into categories that stipulate handling requirements and control measures are specified for disposal facilities.

Standards for the location, maintenance and operation of landfill sites are stated in Section 11 of Regulation 347. Section 9 of the Regulation additionally states that the terms and conditions of the Certificate of Approval can, on a site specific basis, over-ride the standards of the Regulation.

For industrial and commercial waste and certain other wastes (e.g., spill clean-up materials), the leachate extraction procedure described in the Regulation is often used to assist in determining the acceptability for landfilling at sites approved to receive municipal waste.

e) The Municipal Act and Related Acts

The Municipal Act grants municipalities with powers that include the authority to assume waste management activities.

Section 210, Paragraph 90 of the Municipal Act stipulates the requirements concerning approval of the local municipality or the Ontario Municipal Board (OMB) for acquiring land in other municipal jurisdictions for the purpose of establishing a landfill site. Part (b) of Paragraph 84 describes the provisions of the OMB hearings procedure in the decision to permit or disallow the use of land for the purpose for which it is to be acquired.

Paragraph 135 of Section 210 of the Municipal Act describes the extent of local municipal authority in the control of land used for purposes of landfilling within the jurisdiction of the local municipality.

Section 209 of the Municipal Act describes the provisions empowering a county to assume, on a permissive basis, waste management responsibilities and implement waste management system, which may include landfill sites.

Specific Acts governing the establishment and operation of various Regional, District, or Metropolitan municipalities (upper tier municipalities) give these municipalities responsibilities and authority for certain aspects of waste management and pollution control. The relevant Act(s) should be referred to for waste management system and landfill operations located within such municipalities.

f) The Planning Act

The Planning Act, administered by the Ministry of Municipal Affairs or delegated municipalities, sets out the ground rules for land use planning in Ontario, and establishes how land uses may be controlled and who may control them. The Act provides the basis for consideration of provincial interests related to municipal land use planning, such as management of natural resources and farm land, preparation of official policies and plans to guide future development, and regulation and control of land use.

The planning and approval of a landfill site will involve the Planning Act when property needs to be purchased for landfilling purposes. If the existing land use for the property as described by the zoning by-law and/or Official Plan does not conform to this type of land use, a zoning change or Official Plan amendment by the municipal government will be necessary.

g) **Other Legislation**

Other legislation relevant to landfills include but are not limited to the following:

i) Consolidated Hearings Act;
ii) Expropriations Act;
iii) Ontario Municipal Board Act;
iv) Conservation Authorities Act;
v) Surveys Act of Ontario;
vi) Aggregate Resources Act;
vii) Pesticides Act;
viii) Occupational Health and Safety Act;
ix) Health Promotion and Protection Act;
x) Drainage Act;
xi) Local Services Board Act;
xii) Public Lands Act;
xiii) Fisheries Act (federal); and
xiv) Air Transport Act (federal), which provides for control of land uses in the vicinity of airports and flight paths.

1.2.2 Certificate of Approval

The Certificate of Approval is required for the establishment, operation, management, alteration, extension or alteration of a landfill site. Application is submitted by the owner(s) of the (proposed) facility, and upon approval, a Certificate is issued by the MOEE under the provisions of Part V, Section 27 of the EPA. All landfill sites must possess a valid Certificate of Approval and must be managed and operated in compliance with the terms and conditions that are contained in the Certificate.

The conditions included in a Certificate of Approval for a landfill site are specified on a site specific basis and can impose additional requirements or emphasize important features of site design, monitoring and operations.

The process of acquiring a Certificate of Approval for a proposed landfill site commences with consultation with the appropriate Regional or District Office of the MOEE to ascertain the supporting information and documentation necessary for submission with the formal application. The process of approval involves procedures stipulated under the EAA and the EPA as described in Subsection 2.2.

Additionally, other approval can be required under Sections other than Part V, EPA or under other Acts. Approval is required under Section 9 of the EPA for any control equipment and air emissions in the case of contaminant discharge to the atmosphere. Where a disposal site

involves the discharge of sewage, which includes surface drainage, to surface water, or the extension, enlargement or alteration of the leachate treatment system, approval may be required under Section 53 of the OWRA.

1.3 STAKEHOLDERS AND THEIR ROLE

It is essential that all parties understand their respective roles and actively participate in the process of waste management by landfilling. Various levels of government have responsibilities in controlling and regulating landfilling operations to ensure compliance with regulations, approval conditions and municipal by-laws. Owners and operators of landfills have a responsibility to efficiently operate, manage and monitor their sites in order to prevent any negative impact on public health and safety and on the environment. The community being served by a landfill has a responsibility to ensure that waste diversion is maximized by actively participating in 3Rs programs. Collectively, all these stakeholders can contribute significantly to effective landfilling practices.

a) Municipalities and Local Authorities

Traditionally, the municipalities have assumed the responsibility for the development of waste management programs to suit the specific needs of their respective local communities. A majority of the landfill sites in Ontario are owned and operated by the municipalities.

The preparation of long-term comprehensive waste management plans for a community, could be prepared by the local municipality. However, collective planning by a group of several local municipalities or upper tier municipalities such as regional municipalities or counties, is encouraged. Landfilling is usually one component of such a plan which will include numerous waste management programs, including 3Rs programs. The municipalities must ensure that all relevant information on their waste management programs are available to the public and that the public is involved in the decision making process in the development of the waste management programs.

Municipal authorities can also act as coordinators for liaison between representative public and citizens' groups from the community, provincial regulatory bodies such as the MOEE, and landfill owners/operators (which in many cases will be the municipalities themselves).

The application and enforcement of relevant municipal by-laws whether for public or environmental security is carried out by local municipal authorities under the provisions of the Municipal Act. Ensuring land use compatibility between landfill sites and other land uses in the vicinity of the site, through effective planning and land use control is another vital function of the municipalities.

b) Provincial Government

Ministry of Environment and Energy (MOEE)

The MOEE functions as the role of regulator of waste management practices through:

i) the effective application of the provisions of the EPA and the EAA in ensuring safe disposal of waste. This responsibility is implemented through:

- ensuring that potential landfill sites are identified through a rational and open planning process, in which the preferred site has the least effect on the environment,
- accepting, accepting with modifications, or rejecting an Environmental Assessment,
- evaluating technical merit and acceptability of waste management projects,
- issuing Certificates of Approval for landfill sites,
- establishing and enforcing site-specific performance levels, for example, the Reasonable Use Concept,
- reviewing annual or status reports on landfill sites to ensure compliance with the Certificates of Approval,
- inspecting landfill sites,
- regulating the reuse of closed landfill sites,
- implementing government policies on waste management practices with respect to landfilling, and
- enforcing legislation;

ii) the development and implementation of policies and programs to support municipalities and industry by:

- providing technical or financial support for 3Rs programs, comprehensive long term waste management planning and new or improved waste treatment/disposal facilities,
- providing guidelines,
- promoting and conducting research and studies;

iii) the assumption of a leadership role in providing proponents and the public with guidance and advice in providing support of undertakings that meet the requirements of Ontario's environmental legislation and in promoting awareness of resource conservation and responsible waste management.

Ministry of Municipal Affairs (MMA)

The MMA is responsible for municipal government and community planning in the province. It ensures municipalities have the legislative authority to respond to local needs, including waste management, and offers management and administrative support along with financial assistance to approximately 830 municipalities across Ontario.

The MMA encourages sound planning at the community level and renewal activity in municipalities through operational and technical assistance.

Ministry of Natural Resources (MNR)

The purpose of the MNR is to provide opportunities for resource development and outdoor recreation for the continuous economic and social benefit and to administer, protect and conserve public lands and waters. The MNR is concerned with the use of the physical resources of land, water, trees, fish, animals and certain minerals for resource utilization and recreation.

In unorganized areas of the Province, especially where no nearby municipal authorities exist, MNR has assumed the responsibility of establishing and operating landfill sites for the disposal of domestic and other non-hazardous wastes. The MNR owns and operates approximately 320 landfill sites on Crown land across the Province.

c) Federal Government

Various statutes of legislation and related regulations concerning the protection of the environment have been established and are administered by federal authorities such as the Environment Canada, Atomic Energy Control Board, Energy Mines and Resources Canada, Transport Canada and the Federal Department of Fisheries and Oceans.

The areas of exclusive federal jurisdiction, including native lands, (some) airports, military bases and other federal facilities are regulated by federal agencies and subject to federal legislation but not subject to provincial legislation. In most cases, the federal facilities voluntarily conform to provincial requirements. Both the federal and provincial governments are continuing to work together to ensure that the areas of federal jurisdiction within Ontario, also conform as best possible to the environmental standards and requirements that apply to the rest of the Province.

d) The Public

The households generate 40% of the solid (non-hazardous) wastes in Ontario and bear some of the responsibility for maintaining and operating landfill sites. The public has a responsibility to provide informed input in the decision making process on waste management issues in their communities. Public participation in the decision-making process greatly assists municipal authorities and other proponents of landfills in the establishment of goals and objectives and in the preparation of evaluation and assessment criteria that would help in resolving siting conflicts. Through participation in the decision-making process at public hearings and public meetings, community representatives can voice their concerns and communicate public opinion and requirements on specific waste initiatives and undertakings.

Through purchasing choices and active participation in provincial, municipal or community waste diversion and other 3Rs programs, the public can reduce waste quantities that require disposal at landfill sites.

Maintaining close liaison with owners and operators of landfill sites throughout the operational life of a landfill, provides a better understanding of the process of waste disposal at sites and helps ensure quick resolution of issues that cause concern.

e) Private Sector

The role of the private sector in managing solid waste is an important one. The private sector generates 60% of the municipal waste in Ontario and bears some of the responsibilities and cost of waste management. As generators of waste, the private sector collectively can make a major impact on landfill resources by effectively implementing waste reduction, reuse and recycling programs. Industrial and commercial waste generators could implement waste and packaging audits and waste reduction work plans designed to maximize the diversion of waste from disposal. Private sector commitment to government waste diversion initiatives is vital if provincial goals and targets are to be met.

As proponents and managers of waste management facilities, the private sector has a responsibility to ensure that the operation of the facilities comply with the requirements for securing public safety and maintaining environmental integrity.

Generally, the private sector is credited with being at the leading edge of advancing technology in waste management and energy recovery. The continued development of new and innovative methods in handling and processing wastes is essential in preserving and increasing the capacity and service life of diminishing landfill resources.

f) Professional Services

It is generally advisable for landfill owners and operators to obtain professional assistance in preparing proposals, assessments, applications, supporting documentation and plans, and carrying out studies and investigations for the preparation of submissions and status reports. Assistance can be provided by qualified professional engineers, hydrogeologists, hydrologists, ecologists, planners, lawyers and others.

Regardless of who has prepared the tasks, it is landfill owners' responsibility to ensure that all assessments, investigations, designs, documentation and reports are accurate and prepared in sufficient detail to satisfy the regulatory requirements and authorities and that the public has been provided opportunities to participate in the establishment of the waste management facility. It is also incumbent on the landfill owners and operators to demonstrate to the MOEE and the public that the site will not have an adverse impact on the environment or public health and safety.

1.4 FULL COST OF LANDFILL SITES & FINANCIALLY SUSTAINING SYSTEM

The Government of Ontario is fostering discussion on a framework for financially sustaining waste management systems in Ontario. A financially sustaining system should possess the following attributes:

- ensure sound resource allocation decisions with respect to waste management by all stakeholders, including governments, institutions, commercial organizations and individuals;
- ensure funds are available to off-set the operating and capital expenditures for a waste management system, which may include 3Rs (reduce, reuse, recycle) facilities or landfill sites;
- generate revenue from those benefitting from the waste management system;
- ensure the owner/operators can finance, maintain and develop their waste management system, including the landfill component, with less dependence upon operating subsidies or capital project grants from the Province; and
- may involve setting up reserve fund to finance future large capital expenditures, such as 3Rs facilities or replacement landfill sites.

To ensure sound fiscal planning, the full cost of the landfill site should be known for all aspects, including planning, design, approval, development, operation, management, maintenance, closure, post closure and any environmental and socio-economic costs. This is the only way to ensure that all costs are recognized for potential recovery.

The tipping fee established at the landfill can be a source of revenue needed to off-set the costs of providing sanitary waste disposal by landfilling. Further, the landfill can contribute towards off-setting the costs of the waste management system. For the municipalities, the property tax serves as another, albeit, indirect means of revenue for municipally owned landfill sites.

SECTION 2

PLANNING AND APPROVALS

2.1 INTRODUCTION

Implementation of an effective, cost efficient and environmentally sensitive landfill operation requires sound planning based on an integrated approach to waste management. Fundamental to the planning of landfills in Ontario, is the reduction of waste through implementation of 3Rs programs. The planning for the establishment and development of a landfill should commence with the consideration and evaluation of all waste management alternatives. The planning of a landfill under the EAA requires proponents of a landfill to consider "alternatives to" (such as systems, technologies and processes) and "alternative methods" to landfilling. The evaluation of alternatives must consider the full scope of the environment which includes the natural, social, technical, economic and cultural aspects. Generally, the development and establishment of small landfills receiving municipal waste are not subject to the EAA, nonetheless, the fundamental principles and concepts of the environmental assessment process are encouraged.

This section provides information on some of the planning aspects for selecting the most feasible and environmentally sound waste management option. It then briefly outlines the approvals process that precedes the establishment of a landfill facility as a component of the preferred and recommended option. The process of obtaining approval for the continuation of use, or for the expansion of a landfill site is similar, and is also discussed. Public input and involvement should also be sought during the planning stages and also in the decision-making process.

Planning of a landfill could consider the feasibility and benefits of adopting multiple waste management activities at the site. Consideration should also be given early in the planning stages to potential end uses of the closed landfill site. This section also provides information on multiple activities that may be initiated at landfills, and the planning and regulatory issues dealing with end-use.

2.2 LANDFILL PLANNING AND APPROVAL PROCESS

All proponents, public or private, should develop and follow a plan for siting and establishing landfill sites. Planning of landfill sites must satisfy the provisions of the EPA, EAA, OWRA, other relevant Acts (e.g., Municipal Act, Planning Act). Subsection 2.2 provides general information on the planning and approval process for landfill sites. The flow chart, Figure 2.2 (A), illustrates a basic summary of the approval process under the EPA and EAA. The detailed information and technical requirements under the EPA are discussed in Section 3.

Landfill proposals/projects can be subject to hearings, where areas of concern are publicly raised. Landfill proposals to receive waste equivalent to domestic waste of 1,500 persons or more, require a mandatory hearing under Section 30 of the EPA; this in turn triggers the application of the EAA. For smaller landfill proposals/projects, discretionary EPA hearings can be held. The approval process is concluded with a decision of the appropriate authority (for example, the Hearing Board) to grant or deny approval. Where the proposal/project is approved, the landfill owner is issued a Certificate of Approval under Part V of the EPA.

2.2.1 Landfill Site Selection Under the EAA

The selection of preferred site(s) for the establishment of a landfill site is an important aspect of an environmental assessment. The environmental assessment process involves a wide range of planning issues and is briefly outlined in this subsection. *Details on the preparation of an environmental assessment or on the contents of the environmental assessment (EA) document are beyond the scope of this Guidance Manual.* The users of the Guidance Manual are advised to consult the Environmental Assessment Branch of the MOEE for details on the EA requirements or review the EA information documents listed in Appendix II.

Where the EAA is applicable, an environmental assessment (EA) document must be submitted explaining the planning process followed and the decisions made to select the preferred site from the various alternatives. This environmental assessment process has evolved through necessity to provide local communities, users of landfill sites and regulators with the confidence and assurance that all applicable social, cultural, environmental, economic and technical issues receive due consideration in the decision making process with the main objective being to minimize risk to public health and the environment.

The key elements of the environmental assessment process are as follows:

i) Consultation with the MOEE on the requirements of the EAA and the approvals process;

ii) Consultation of the undertaking with interested ministries, agencies and public groups to address and deal with their concerns. It is beneficial for proponents to present basic information on the project to these groups at this stage. The information may include the purpose, the candidate areas, alternatives that need to be considered, a preliminary listing of issues, and relevant studies to be carried out;

iii) Preparation of the EA document and submission to the MOEE;

iv) Review of the EA document by the MOEE in consultation with those ministries, agencies and groups that have an interest in the proposed project;

v) Publication of a government review document by the MOEE with an opportunity for interested parties to submit comments;

vi) Decision by the Minister of the Environment on whether a hearing should be held before the Environmental Assessment Board;

vii) Provision of any additional information by the proponent in response to the review and public comments and presented in support of the EA during a hearing;

viii) Decision by the Minister of the Environment or the EA Board, where a hearing has been held, on acceptance of the EA and/or approval of the undertaking, followed by a 28-day period during which the decision may be appealed; and

ix) When an undertaking is approved under the EAA, conditions or requirements may be specified. In addition to EAA approval, a Certificate of Approval under Part V of the EPA is also required and may include additional conditions of approval. As well, OWRA or Section 9 EPA approval may be required.

2.2.2 Landfill Site Selection Under the EPA

Planning of small landfill sites generally are not subject to the EAA. For example, the planning of small landfill sites receiving waste equivalent to domestic waste of less than 1,500 persons, do not require mandatory hearing under Section 30 of the EPA. Approximately two-third of the existing landfill sites in Ontario, particularly in rural or northern areas, would fall under this small landfill category.

For the benefit of those establishing a small landfill under the EPA, this subsection outlines general planning steps that may be followed. Although the planning of small landfills are not

subject to the EAA, the fundamental principles and concepts of the environmental assessment process are encouraged.

a) Evaluation Criteria

An important facet in the site selection process is the development of the evaluation criteria that will be used for identifying and evaluating suitable sites. Under the EPA, potential impacts on the natural environment and nuisances (e.g., traffic, noise) must be considered. Proponents should seek public input during the process of developing the evaluation criteria. Consensus among the proponent, the MOEE, other ministries and the local community is desirable in the development of such criteria. Consensus, however, may not be achievable and is not essential.

b) Systematic Screening

To determine a few candidate sites, a systematic screening procedure utilizing the developed evaluation criteria, is followed. This screening procedure may be supported by reconnaissance level studies. Preliminary assessment and further systematic screening of the candidate sites leads to the selection of one (or more) preferred site(s) requiring greater detailed assessment.

i) Identification of Candidate Areas

This is the first step in the screening procedure. It consists of the preparation of an environmental data base of the study area under consideration using existing information (topographic, geologic, hydrogeologic, soils, and land use maps), zoning designations, aerial photographs, Water Well Records(Form 9, OWRA), sensitive biological habitats and other generally available data. The objective of this step is to research the area and identify the bio-physical setting as it relates to the suitability for landfilling.

Potentially suitable land areas, sometimes called 'candidate areas', are selected by using the data base, for example, utilizing a constraint mapping technique where a series of overlays of information are superimposed on one another. Areas are selected based on the greater net benefit or least negative net impact that would be imposed on the environment by establishing and operating a landfill.

ii) Identification of Candidate Sites

This is the second step in the screening procedure. It consists of conducting a more detailed examination of those settings identified in the first step and judged to have the most potential for establishing sites suitable for landfilling. It is in this step that specific sites are selected for which conceptual landfill designs, incorporating appropriate mitigation measures, will be proposed.

iii) Assessment of Candidate Sites

This step involves a preliminary assessment to rank specific candidate sites in order of preference. The ranking system considers the potential impact of a deficiency in the landfill system, for example, impact on water resources. The ranking should take into account the natural attenuation available or corrective/mitigative measures (e.g., leachate collection system) that could be implemented. It is at this stage that conceptual designs are prepared and submitted in an initial report. The conceptual design should include a general discussion of site monitoring and contingency measures.

For example, from the hydrogeological perspective, it is important to establish the level of engineering required at each site for safe landfilling. This permits comparison between candidate sites as to their particular advantages and disadvantages. In addition, mitigation measures necessary to make the overall operation of each landfill environmentally safe and less of an impact upon the community are identified.

The assessment may take place in one step or may be phased by an initial assessment to identify more suitable sites, followed by a more detailed comparison to identify the preferred site(s).

c) Detailed Assessment of the Preferred Site(s)

The detailed assessment involves the process of predicting the migration of landfill generated contaminants, the rate and extent of their attenuation and the potential effects on all aspects of the environment including air, water resources, land uses, public health and safety of the local community. Typically, the detailed assessment is carried out the level of detail necessary to obtain EPA, Part V approval.

Detailed assessment of the selected site(s), for example, can include the preparation of the following:

- detailed hydrogeologic evaluation;
- site plan for design and operations, including leachate and gas control measures;
- contingency plan;
- monitoring programs;
- measures to minimize visual, noise and odour impacts;
- closure plan;
- traffic study;
- biological impact assessment; and
- economic and community impact study.

2.2.3 Public Hearings

Applications for establishment of landfill sites may require public hearings under the EPA and/or the EAA. These hearings are held before the Environmental Assessment Board, a body that is independent of the Government. During the hearing, all information and pertinent issues related to the proposed establishment of the site are raised, providing all participants and recognized public bodies, such as citizens' groups, with an opportunity to voice concerns. Hearings are concluded with the Board decision to either grant or deny approval for the proposal. Approval is generally subject to compliance with specified terms and conditions, usually set forth in the notice of approval.

The following groups normally participate at the Environmental Assessment Board hearings:

i) the proponent, who is normally the owner who proposes the establishment and operation of a site;
ii) any person, persons or organization, such as local citizens' groups, municipalities and other government agencies; and
iii) the Ministry of Environment and Energy.

a) Hearings Under the EPA

A discretionary EPA hearing may be held for any landfill not falling under the mandatory hearing provisions of the EPA, Section 30. The hearing under Section 32 of the EPA can be required, normally at the discretion of a MOEE Regional Director, for small-scale landfill proposals/projects. The guidance for determining the need for discretionary hearing is provided by the MOEE Policy 14-01, Guidelines for Hearings on Waste Disposal Sites.

An EPA hearing is held before the Environmental Assessment Board and considers the technical acceptability of the proposal, such as hydrogeology and technical design of the landfill. At the conclusion of the hearing, the Board issues a report on its decisions and requires the MOEE Regional Director to implement the decision, such as issuance of the Certificate of Approval. Upon such Board decision, a 30 day public review and appeal period is specified.

b) Environmental Assessment Board Hearings Under the EAA

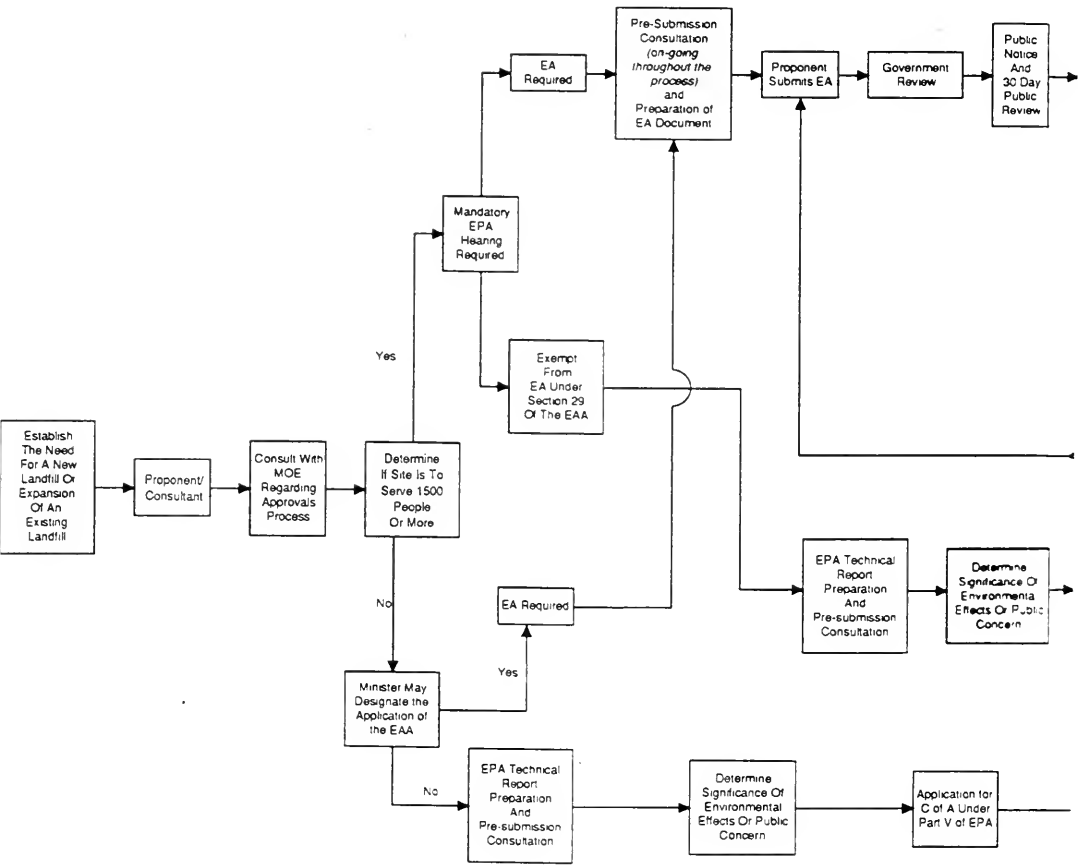
The EAA is applicable to those proposals/projects requiring mandatory EPA hearing under Section 30. If under the EAA, the hearings also consider the proponents' planning process to ensure that the requirements of the EAA have been fully addressed. Hearings are concluded with the Board decision on EA acceptance and approval to proceed or, where the Minister has accepted the EA, Board decision on approval to proceed only. The Board decisions become final and binding in 28 days, unless a participant in the hearing process files an appeal for judicial review or if there is an appeal to the Cabinet on the decision.

c) Joint Board Hearings Under the Consolidated Hearings Act

When a project requires approval under several Acts and before several boards, the Consolidated Hearings Act provides for a single hearing to avoid the added time and expense associated with multiple hearings. The Acts that may be satisfied by Joint Board hearings include, among others, the Environmental Protection Act, Environmental Assessment Act, the Expropriations Act, the Ontario Municipal Board Act, the Ontario Water Resources Act, the Municipal Act, the Planning Act and the Conservation Authorities Act.

A consolidated hearing may be chosen by the proponent or requested by other parties. The proponent wishing a consolidated hearing must give written notice to the Hearings Registrar, explaining the general nature of the undertaking, the hearings that may be required and the Acts in question.

SUMMARY OF APPROVAL PROCESS FOR



* *The Application For A Certificate Of Approval (CofA) Under Part V Of The EPA And The Necessary Supporting Technical Documentation Will Be Submitted For Review In This Hearing.*

FIGURE 2.2 (A)

LANDFILL SITES RECEIVING MUNICIPAL WASTE

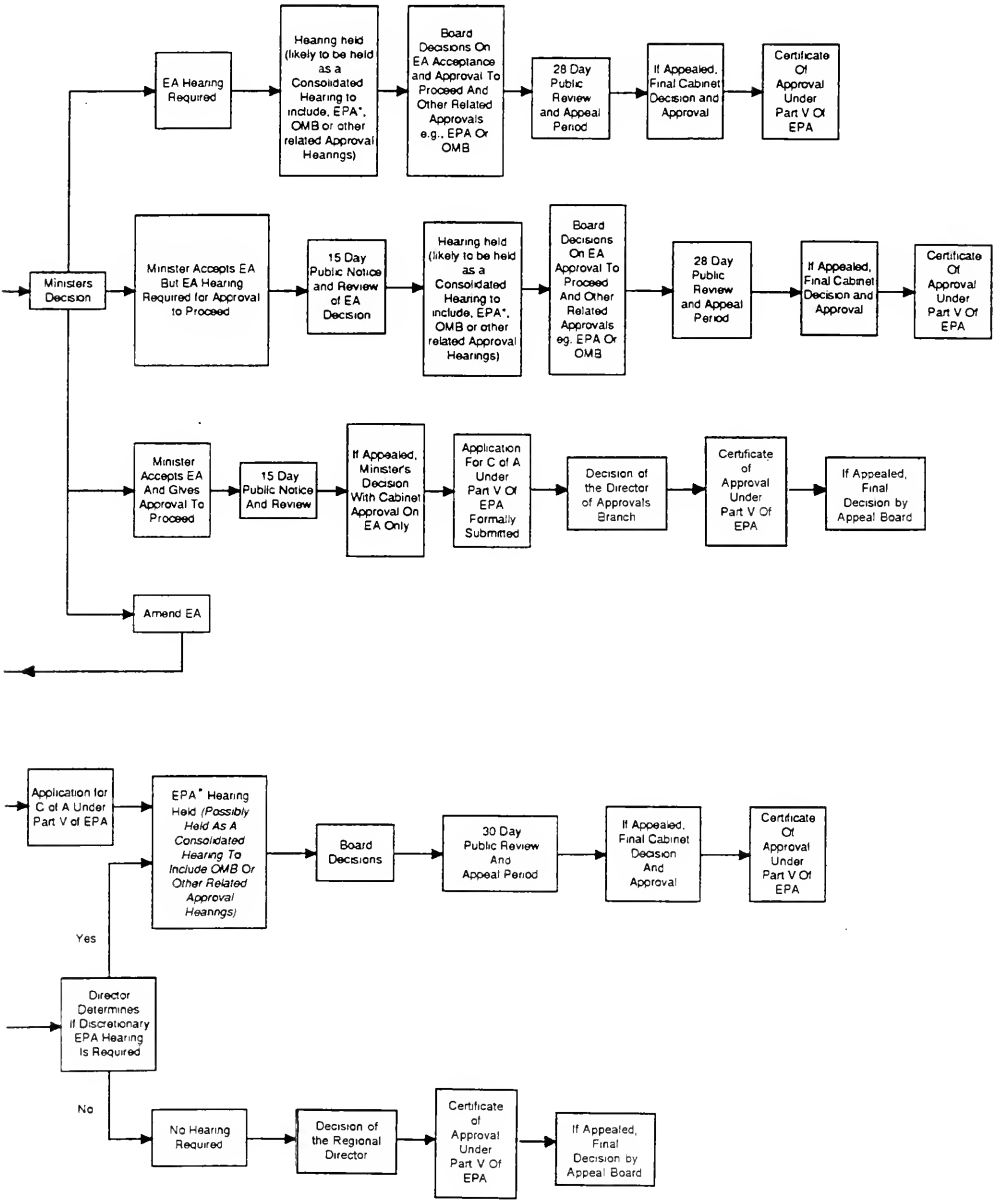


FIGURE 2.2 (A) - Con't

2.3 PLANNING FOR END USE

End use is the intended use of the landfill site following formal closure with the establishment of final cover, landscaping, vegetation and other structures or facilities.

Landfill sites possess the potential to generate contaminants which are hazardous to humans, animals and plants and which can pollute and degrade the environment in the vicinity of the landfill site. Contaminant generation and migration from the landfill site can continue for many decades after the closure of the landfill. Therefore, legislation has been brought into effect to protect communities and the public in general from the potentially harmful effects of landfill pollutants. Section 46 of the EPA stipulates that no use shall be made of land which has been used for the disposal of waste within a period of twenty-five (25) years from the year in which such land ceased to be so used, unless approved by the Minister. Although MOEE restriction on reuse of the site is twenty-five years following formal closure, the landfill owner should not assume that the potential to generate contaminants will be eliminated after twenty-five years, and as such, MOEE approval will always be needed. MOEE Policy 07-07 provides information on issues that should be addressed in proposals for land use on or near landfill sites.

It is important to understand that the existence and enforcement of the above mentioned legislation is for the protection of adjacent land owners and future users of the site itself. A landfill site is a necessary disposal facility for waste generated by a community which can, with foresight, be converted to a community asset following closure. Converting a closed landfill site into usable aesthetically acceptable land is a beneficial end use. Consequently, adjacent land becomes more desirable and more valuable. The end use should be an important part of landfill planning. Any proposed end use would be subjected to careful review by the local municipality and the MOEE and should consider input from the public.

Some communities have converted closed landfill sites into municipal golf courses, baseball diamonds, soccer fields and parks. Others have built ski and sled runs. It is being increasingly recognized that planning and designing a landfill in a manner that would prove compatible with, and be beneficial to, its intended end use is the most cost effective method of preparing the land for future development which may generate public support for the establishment of the landfill. Proponents are advised to consider the benefits of making presentations of the plans for a landfill site at service clubs and community meetings with visuals that show planned, attractively landscaped sites and architectural renditions of post closure land use.

It must be noted that approval of land occupied by a landfill site after 25 years of formal closure in many instances is issued conditional upon the continuation of long-term monitoring and operation of controls of landfill generated contaminants.

Proponents establishing and developing landfill sites should make use of available waste management plans and official plans for the respective region. These plans include projected demographic changes, future land demand and potential use, and socio-economic impact. Planning landfill sites compatible with these projections will ensure that the maximum benefit is derived from intended end uses.

Many aspects of the design and operation of a landfill site have a bearing on it's end use. Some of the more significant are listed below:

i) Design of cell geometry and arrangement; and location of non-filled road access strips and building pad areas.

ii) Final contouring and grading can influence the nature of land use. e.g., ski and sled runs (rolling, undulating terrain); parkland (avoid steep slopes to minimize erosion).

iii) Rapid or delayed stabilization of waste within the landfill.

iv) Capping and final cover systems, such as topsoil and vegetation, have a direct bearing on the potential of closed sites for supporting recreational facilities such as golf courses or sustaining wildlife if conservation is the intended after use.

v) Leachate and gas control systems. Leachate control systems may vary depending on the projected dependence on, and utilization of ground water resources as a source of water supply in adjacent areas. Gas control systems can be appropriately designed with sufficient safeguards and contingency systems to suit building development on adjacent lands. Gas collection and extraction systems can be appropriately designed to suit future energy from waste facilities.

vi) Long term monitoring and inspection programs would depend upon the environmental and safety requirements associated with specific land use.

2.4 EXPANSION OF EXISTING LANDFILL SITES

Circumstances may arise which will result in the consideration of expanding an existing landfill site. The first is the continued use of a site under a short-term emergency Certificate of Approval, to alleviate an emergency situation. The second is an interim expansion of an existing landfill while longer-term waste management projects are being developed. The third, involves the option of expanding an existing site which may have been indicated to be desirable by an environmental assessment process.

2.4.1 Emergency Expansions

If an emergency situation exists, a Certificate of Approval for the extension or expansion of a landfill facility may be granted, under the provisions of Section 31 of the EPA. An emergency Certificate of Approval will usually impose conditions as to the duration of the approval along with other conditions.

An emergency situation may arise, for example, when a community does not have access to a disposal facility for safe and sanitary disposal of waste. Such situations can occur when the landfill being used by the municipality has reached approved capacity before alternative facilities are established through the normal approval procedures.

2.4.2 Interim Expansions

The MOEE Policy 03-05 "Environmental Assessment Act - Interim Expansion of Municipal Landfills" applies to municipalities whose existing landfill site(s) is expected to reach capacity before an environmental assessment is approved and a disposal site fully operational. The proponent may request an exemption from the EA for the short term continued use or expansion of an existing landfill while long term waste management projects are being developed. It should be noted that the requirements of the EPA must be fully met.

The policy applies to municipally owned landfills and private sector proponents who are providing a service on behalf of a municipality. The policy does not apply to hazardous or liquid industrial waste disposal sites.

The objectives of the interim expansion policy include the following:

i) To ensure adequate interim disposal capacity exists for the proponent;
ii) To allow planning of long term solutions to proceed;
iii) To encourage the proponent to identify and resolve issues to the fullest possible extent before an exemption request is submitted; and

iv) To minimize duplication of effort by all parties.

To meet the requirements of the interim expansion policy, a proponent must meet the criteria outlined in the MOEE Policy 03-05, that include being in the process of developing an environmental assessment for a long term solution to its waste management problems.

Normally, an environmental assessment would have to be prepared and formally processed under the EAA. However, in this circumstance, the Minister of the Environment would consider granting an EAA exemption order (Section 29 of the EAA) as long as the terms of the interim expansion policy had been met. If granted, the exemption would allow the proponent to proceed to the mandatory EPA hearing.

When an exemption order for the undertaking is granted, the duration of the interim expansion is a maximum of 5 years from the issuance of the Certificate of Approval. Other terms and conditions may apply to this approval.

2.4.3 Expansion of the Landfill as the Preferred Option

An environmental assessment site selection process may identify the expansion of an existing site as a preferred option. In such circumstance, the normal EA process applies.

2.5 MONOFILLING OF WASTE

Monofills are landfills receiving one type of waste for disposal. Monofilling is generally more applicable to non-hazardous solid wastes that can be or has been isolated from the municipal waste stream that includes diverse mixture of domestic, industrial and commercial wastes. Monofilling may be feasible, for example, for incinerator ash, gypsum (dry-wall) waste, wood waste, pulp and paper waste. Monofills may be at a separate, dedicated disposal cell(s) within a landfill site or at a distinct property. Since monofills are specific type of landfills, same approval requirements apply.

The potential environmental impacts of monofills are considered to be similar to that of landfills and thus this Guidance Manual is applicable to monofills. However, in recognition of monofilling of a specific waste type, some of the design and operating procedures and measures may not be applicable. For example, in the absence of domestic waste or putrescible materials, impacts such as odour, vectors and vermin, daily cell cover and landfill gas control may be of less concern for monofilling. With respect to the impact of monofills on the ground and surface water on adjacent properties, monofills are treated in the same manner as landfills. The design and operational requirements necessary for monofills should be determined on a case-by-case basis. Where monofill cell is part of a landfill site, the combined impact of the monofill cell and landfill cell(s) should be assessed.

One of the benefits of monofilling of a specific waste may be the possible recovery of the monofilled waste material at a future date for resource recovery. Where a monofill cell within an existing landfill site is planned to be exhumed, appropriate records of type, quantity, and location of the waste should be kept.

2.6 PUBLIC PARTICIPATION

Public consultation policies, that have now been established, confirm the commitment of the Government of Ontario to involve the public on matters affecting the environmental. The role of the public and the forum for public consultation and input in selecting and establishing a landfill site is described in earlier subsections. However, the involvement of the public does not and should not end with the selection and establishment of a landfill site, but include on-going dialogue throughout the operating life of the landfill.

Continuing the process of public involvement through co-operation and liaison with public bodies and representative citizen's groups, ensures

- good community relations and a better understanding of the role of landfilling in waste management, and
- the availability of a mechanism for identification and resolution of issues and concerns of the public.

Landfill Liaison Committee

The formation of a landfill liaison committee made up of representatives from the site owner, operator, the local municipal authority and members of the local community is a highly effective means of establishing open communication channels.

The committee could play a role in monitoring the operation of the landfill. The public could be advised to communicate all complaints and concerns to the committee, as well as, to the site owners and operators. These complaints could range from odour, noise or dust related problems and well contamination to broader ranging environmental issues. The committee could act as a coordinating body to address these issues. Coordinating dialogue among the public, and owners, operators, regulatory authorities, (such as the MOEE, other government ministries, the medical officer of health, municipal officials and conservation authorities), will eliminate unnecessary delays in dealing with complaints.

As part of a comprehensive program for public liaison and involvement, the landfill liaison committee can request the landfill owner or operator to provide copies of relevant documentation on landfill issues, but not limited to the following:

- copy of the Certificate of Approval;
- status or annual reports for operating or closed site;
- proposals, if any, for changes in site design or operation; and
- proposed site closure plan or development proposal for closed site.

The committee can facilitate the following means of communications between the public and the landfill owner/operator or the local municipal authority:

- media announcements and newsletters, including distribution strategies (e.g., newsletters to be mailed along with municipal property tax bills);
- annual or semi-annual briefings;
- seminars;
- organized field trips to the local landfill site;
- public meetings;
- environmental fairs; or
- open houses.

2.7 PLANNING FOR COMPLEMENTARY WASTE MANAGEMENT ACTIVITIES

The Government of Ontario has established targets to decrease waste going to disposal by at least 50 per cent by the year 2000 compared to the base year of 1987. Although the targets apply to the Province as a whole, individual waste generators in municipal, industrial, commercial and institutional sectors are encouraged to strive to exceed these targets whenever possible. Many companies and organizations report that they already have.

The provincial strategy is to change the management of municipal waste from an approach which focuses on simply disposing of waste to an approach which focuses firstly on reducing waste generation at the source, and then reusing and recycling (3Rs) the materials which do enter the waste stream. This 3Rs oriented strategy is aimed at:

i) conserving natural resources,
ii) extending existing landfill capacity,
iii) lessening the need for new landfill capacity, and
iv) reducing environmental and social impacts of waste disposal.

The waste quantity reduction system suitable to a particular community will vary depending on both the waste stream and the waste quantity requiring processing, treatment and ultimate disposal. Each individual community can therefore endeavour to target certain materials in their waste stream to reduce the overall quantity requiring disposal. Reduction strategies and waste management options that are employed is a function of the economic and environmental interests of the community, and waste reduction objectives of the community and the Province.

Often, it is difficult to identify suitable locations for waste management activities, including 3Rs facilities. Where a waste management site has been located, the land can be used to its full potential by establishing more than one waste management activity. In some cases, it may be desirable to use a landfill property to process the waste to complement the landfilling operation while in other cases there may be a need for off-site property suitable for this purpose. When new landfill sites are being developed or planned, consideration should be given to dedicating areas on the site to accommodate suitable waste processing plants or operations. Similarly, for existing sites, consideration should be given, on an on-going basis, to optimizing the landfill operations and approved capacity by implementing waste quantity reduction activities.

Subsection 2.7 describes the waste management practices that could be employed separately or in combination at a landfill site and in conjunction with normal landfilling practice. The feasibility of the implementation of one or more of these practices should be addressed on a site and community specific basis. Active and routine evaluation of the need to increase or modify existing waste management practice is strongly encouraged.

In cases where more than one waste management initiative is actively considered for a single property and where different regulations, conditions, policies or guidelines would apply if only a single application were undertaken, the most stringent regulation, policy, guidelines or condition will be applied to the entire site. **Certificate of Approval under Part V, Section 27 of the EPA is required, in many of the cases, for establishing such facilities.**

a) Materials Recovery Facility (MRF)

Recycling requires that waste materials are either separated at the source of waste generation or after collection. MRFs are waste processing sites that are employed after collection.

At a MRF, the waste materials are manually or mechanically sorted to recover items such as glass, metals, plastics, wood, white goods, paper and cardboard. Typically, the material recovery system consists of a series of conveyors leading up from the tipping floor and carrying commingled domestic wastes to areas where the wastes are sorted and segregated into separate bins or stockpiles. Mechanical sorting can be accomplished by means of magnetic separators, screens and ballistic separators. The sorted materials are then baled, compacted, crushed, or otherwise densified prior to shipment to market. Materials not suitable for reuse or recycle are sent for disposal.

Wastes that have been separated at the source can be further processed at a MRF. For example, the separation of wet from dry wastes partially at the source generally results in simplified waste recovery at a MRF.

Although communities of any size could develop a MRF, cost effective and successful implementation of MRFs require relatively large waste quantities and markets for the recycled goods. MRFs are normally most feasible when associated with larger sites and communities. A Certificate of Approval under Part V of the EPA is required for a MRF.

b) Wet/Dry Recycling and Material Recovery

Under this system, residential waste is separated at the source of waste generation into two components: dry wastes including packaging, paper, newsprint, cardboard, plastics, metals, glass, rubber, wood and textiles; and wet wastes such as food, grass clippings, leaves and other compostable matter. The segregated wastes are then taken to a wet/dry recycling plant, which may be located either at a landfill site, or at an entirely separate location.

i) The wet fraction of the waste is composted and the finished, humus-like product may be used for the landscaping needs of the landfill or the municipality in general. Based on the quality of the compost, other usage of higher value may be appropriate.

ii) The dry wastes are sorted into marketable fractions, compacted and baled for shipment to market. To be effective, wet/dry separation is normally initiated at the source to minimize contamination of dry products with wet wastes.

The successful implementation of a wet/dry recycling system requires significant community participation, careful planning and markets for the recovered goods. Generally, larger municipalities are more likely to be successful in implementation of this system. Implementation of the wet/dry recycling system may initially augment material collected under the blue box program. Since the dry component of the wet/dry system will be similar to that under the blue box program, the latter might be eliminated upon implementation of the wet/dry recycling system.

Separation of household hazardous wastes from the waste stream should be undertaken as an integral part of wet/dry recycling to avoid contamination of the processable wastes.

c) Composting

Composting may be defined as the decomposition of the organic component of the waste stream into a stabilized, humus-like material. The process generally uses kitchen wastes, vegetable matter and yard wastes.

An "Interim Guideline for the Production and Use of Aerobic Compost in Ontario" has been prepared to assist those interested in composting in the selection and/or approval of appropriate aerobic composting methods and the production of quality compost based on good operating practices, compost characteristics, and current MOEE legislation.

The collected organics may be composted in a number of ways including the following:

- The materials may be stockpiled into triangular-shaped rows called windrows, which are normally 3 to 4 meters in width at the base, 2 meters in height and as long as necessary to accommodate the waste stream. The windrows are periodically turned using specially designed equipment or front-end loaders, to promote aerobic conditions within the piles. Windrowing is especially practical for composting leaf and yard wastes.

  The composting process may be enhanced by incorporating a series of perforated pipes below the waste pile to facilitate controlled aeration. This serves to accelerate the process and also to reduce odours.

- In-vessel composting is a more controlled process where raw, compostable wastes are loaded into an enclosed vessel. Within the vessel, the wastes are mechanically mixed, aerated and automatically transported to the opposite end of the vessel, where they are discharged.

The time required to adequately compost the organics depends largely on the type and size of material, temperature, moisture content and aeration rate. The composting in windrows may require up to twelve months to complete. In-vessel composting typically requires from seven to ten days of processing within the vessel and an additional five to seven days of curing outside the vessel.

The product may then be used to enhance soil conditions at the landfill or throughout the community. If a market is not available for the end product, the compost could potentially be used as part of the daily or final cover at the landfill.

The land area needed to compost depends on the process employed, the waste quantity, time to complete the process, the type of waste processing such as sorting and shredding, and other site-specific features such as minimum distances to property boundaries or nearby sensitive land uses.

d) Shredding and Baling of Wastes

Waste volume can be reduced significantly through shredding and subsequent compacting or baling. The resulting waste volume reduction can extend the life of the landfill site.

Shredding comprises feeding the waste into a hammer mill or shearing device to reduce the size of the waste to a smaller dimension. This allows better compaction of the waste. In addition, better uniformity of the waste may promote a more uniform rate of waste decomposition.

Baling consists of compaction of the waste into blocks, which again reduces the volume of the waste and extends site life. In addition, baled wastes are generally more cohesive than loose wastes, thereby minimizing the nuisance created by blowing litter.

The use of shredders and balers can be considered at landfill sites, if circumstances determine their suitability for specific sites. It may be noted that shredding and baling require more site space and equipment; involve double handling of waste; and require modifications in site design. A Certificate of Approval under Part V of the EPA is required to process the waste in this fashion.

e) Tire Shredding

Discarded automobile and truck tires create problems in landfills because they often "float" or partially rise to the surface after they have been buried. This results in uneven settlement of the landfill. In addition, the tires can serve as nesting grounds for rodents and insects. Furthermore, tires occupy a significant landfill volume due to their size and shape.

The reuse or recycling of scrap tires is strongly encouraged. For additional information, review of "Scrap Tire Management in Ontario" is suggested. The topics covered in the report include current scrap tire management practices in Ontario and other jurisdictions, and processing technologies to recycle tires into other products. It should be noted that various approvals may be required under EPA and EAA for storage, shredding or processing of scrap tires.

The difficulty with reuse and recycling of scrap tires lies with the limited markets in the past and the present for processed scrap tires. Where reuse or recycling is not yet possible, nuisance effects of scrap tires at the landfill may be reduced by shredding the scrap tires prior to disposal. Mobile tire shredding systems may be available to service the landfill site on an as-required basis.

f) Wood Chipping

Wood chippers are used to convert pallets, construction wood, logs, branches, tree stumps and brush into chips and mulch. The end product is then commonly used for landscaping applications, ground cover, erosion control, fuel for energy from waste plants and road stabilization at landfills. Generally, care must be taken to produce "clean" wood chips, free of contamination. Various types and sizes of wood chippers are available, many of which are mobile. They can reduce the bulk of some waste wood substantially.

g) Recycling Bins for Small Generators

To increase the quantity of waste material that could be separated and recycled, several recycling bins should be placed at convenient locations at the landfill, usually near the site entrance. Each bin should be appropriately labelled to facilitate proper waste separation by individual site users.

Although recycling bins are suitable and should be employed at all landfill sites to some degree, they may be particularly appropriate at small landfills where large proportions of the waste may be delivered in automobiles and pick-up trucks by residents. Arrangements can be made either to have recyclers collect the sorted refuse, or for the landfill operator to have it hauled to the waste processing plant.

h) Household Hazardous Waste (HHW)

Landfilling of household hazardous wastes (HHW) may potentially degrade ground water and surface water supplies. The purpose of household hazardous waste separation is to reduce even further the quantity of toxic substances disposed of in landfill sites, thereby decreasing the likelihood of contamination of the environment and improving safety for site workers.

Products such as paints, spent solvents, batteries, pharmaceuticals, miscellaneous organic and inorganic chemicals, pesticides, herbicides, compressed gas cylinders, waste oils, etc., are

separated from the general waste stream by residents. Clear identification of the waste by the residents or the site staff is essential to the safety of personnel and proper recycling or disposal of HHW. Several options for separation and collection are listed below:

i) Commonly, residents voluntarily separate and deliver HHW to a HHW depot, established at a waste transfer station or a landfill site, for further sorting and temporary storage prior to transport and disposal at a hazardous waste disposal facility or incinerator.

ii) Another common way is to provide "hazardous waste days", where temporary HHW collection depots are established in a community. On these event days, the residents deliver HHW to the depot(s) for sorting and transport for disposal at a hazardous waste disposal facility or incinerator.

iii) Alternatively, a municipality may provide a mobile collection system, or a "toxic taxi", which travels around the community, stopping at various predetermined locations where HHW is delivered by local residents.

The MOEE has published a document entitled "Guide to Implementing Household Hazardous Waste Collection Programs". Municipalities are encouraged to review this document prior to implementing HHW collection systems.

The incorporation of HHW collection, storage and safe disposal is strongly encouraged for all communities. The HHW facility could consist of either a single permanent building, a dedicated trailer, or several small storage sheds. Safety control devices such as fire and gas alarms, ventilation systems, eye wash stations, non-spark electrical controls, fire extinguishers, drip pans and other similar devices are normally required.

As a minimum, at a HHW facility, the following should be practised:

i) Daily record of waste types and quantities received;
ii) Record of material stored on-site overnight;
iii) Record of when, where and how much material is transferred off-site;
iv) Regular inspection of the facility to ensure security of containers, to record spills or other irregular incidents; and
v) Staff handling HHW should be properly trained and should wear appropriate protective clothing including safety boots, hard hat, safety glasses and rubber gloves. Standard procedures for receiving waste should be developed and followed routinely to ensure safety.

A Certificate of Approval under Part V of the EPA, to allow the acceptance, temporary storage, packaging and bulking of waste is required for a HHW facility.

SECTION 3

PRINCIPLE CONSIDERATIONS IN LANDFILL DESIGN

3.1 INTRODUCTION

Section 3 describes the design philosophy and the fundamental principles of landfilling as a means of managing municipal waste. It also provides information, in generic terms, on hydrogeologic, hydrologic, and geologic criteria that dictate site design parameters. Environmental protection measures such as the contaminant control systems at landfills, performance monitoring and the need for contingency provisions, in case of failure of a primary control system, are discussed to provide an understanding of the principles in the design and development process.

Technical documentation normally necessary for approval under the Part V of the EPA, that is, a Certificate of Approval, is described with the intention of advising users of this Guidance Manual of the submission requirements consistent with legislation and current MOEE policy.

Very Small, Remote and Infrequently Used Landfill Sites

In Ontario, there are numerous landfill sites that are situated in remote locations and operate on a seasonal basis or are used infrequently. They are typically very small in size and located in northern or rural parts of Ontario. Examples include disposal sites that serve logging camps, recreation camps, or a few families in isolated areas. The Ministry of Natural Resources is presently responsible for many such sites in northern Ontario.

As the scale of operations are very small and locations of these sites are remote, the environmental, nuisance and social impacts are considerably less than for other landfill sites. As such, based on site specific conditions, less stringent standards may be acceptable for the design and operation of very small sites. The design and operational parameters discussed in the Guidance Manual should be considered in such context. Very small landfill proponent should develop the site design and operational parameters based on site-specific conditions for the approval of the MOEE Regional Director. The issuance of the Certificate of Approval of very small sites would be the responsibility of the Regional Directors of the MOEE.

3.2 NATURAL ATTENUATION AND ENGINEERED FACILITIES

When selecting new landfill locations, there is a preference for sites in environments that provide natural protection, or in other words, sites where landfill generated contaminants are naturally reduced to acceptable concentrations or naturally contained. Where self attenuation is not possible or adequate by itself, engineered facilities are necessary. It is the responsibility of landfill owner/operator to design and develop, with full consideration of site conditions, landfill sites that can achieve sanitary disposal of waste.

Provided capacity exist in the subsurface to naturally attenuate and adequate buffer is available, landfill design and operations based on natural attenuation are less complex than on engineered facilities. Due to simplicity of design and operations and relatively small land area needed to meet reasonable use criteria, natural attenuation based design is more appropriate for smaller landfill sites. Where natural attenuation is not possible or adequate by itself, such as at larger landfill sites, engineered facilities are acceptable means of providing protection of the environment from the discharge of liquid leachate and gaseous contaminants, and improving aesthetic qualities. The specific engineered facilities that are required on a particular landfill site depend on the environmental conditions that are present and the type of waste, and thus can only be determined on a site-by-site basis. In some cases, such engineered facilities may entail only simple ditching or grading for the control of surface run-off; in other cases, complex leachate and gas control facilities may be required.

In recent years, modern landfill sites are relying on varying degree of both natural attenuation and engineered facilities. Regardless of the reliance upon natural attenuation or engineered facilities or both, environmental monitoring plans and contingency plans are necessary at all landfill sites to provide assurances that the environment has been and will continue to be protected.

Examples of engineered facilities associated with the control of landfill generated contaminants include the design, installation and maintenance of the following:

i) synthetic and/or clay liners beneath a landfill;
ii) synthetic and/or clay covers;
iii) leachate collection systems;
iv) leachate treatment systems;
v) gas interception, collection and venting systems;
vi) facilities for the control of contaminated surface water or ground water;
vii) facilities for "rapid stabilization" of the landfill; and
viii) monitoring systems for ground and surface water and for gas.

With increasing awareness of environmental issues concerning waste disposal and particularly landfill facilities, there will be an increasing reliance on better contaminant control systems.

Engineered facilities can provide effective contaminant control provided the engineered equipments, materials and structures perform to the required specifications.

The preference in Ontario for selecting sites for landfills in locations that provide natural protection and attenuation, contrasts with the approach taken by the U.S. Environmental Protection Agency and the U.S. "Subtitle D" regulations for municipal (solid) waste landfills. U.S. "Subtitle D" specifies as acceptable, a minimum technology standard of a composite liner system for controlling leachate at all new landfills accepting municipal (solid) waste, with provisions for state specific performance standards. In siting of the landfill, site-specific characteristics of the land, such as hydrogeology, is less of a factor, as there is an assumption that technology can overcome any land characteristics undesirable for the purpose of landfilling. Unlike Ontario, it does not include the requirement that the control facilities must function as long as necessary for the duration of the contaminating lifespan of the landfill.

In designing engineered facilities for the control of contaminants, the service life of such facilities should be defined by the landfill proponent. The frequency and the number of times replacement is deemed necessary must be established in order to satisfy the requirement that the service life of engineered facilities exceed the contaminating lifespan of the landfill site. Contaminating lifespan, is the time period during which the landfill will produce contaminants at levels that could have an unacceptable impact, if they were to be discharged to the surrounding environment. The operation, maintenance, monitoring and replacement of engineered facilities including financial considerations in meeting this requirement is a major consideration in the design of a particular landfill.

Users of this Guidance Manual are referred to the following MOEE policy documents for further reference:

- "Engineered Facilities at Landfills That Receive Municipal and Non-Hazardous Wastes" (MOEE Policy No. 14-15),

- "Incorporation of the Reasonable Use Concept into MOEE Groundwater Management Activities" (MOEE Policy No. 15-08).

Design Considerations for Topography and Land Use

Some land forms may not be readily usable for landfilling, however, landfilling may yet be possible with site design and operational considerations for topography and land use.

Operational and/or visual problems will have to be considered where the land has steep slopes. Daily and final cover material can be hauled from far distances, at considerable costs, or alternative cover material can be considered, where sufficient soil is not available on-site. The suitability of abandoned/active pits, quarries and ravines is often assessed, in which case, special designs are usually necessary to protect ground water or surface water from

contamination. Often, it is naturally suitable to locate landfill sites in quality agricultural land. The trade-off between the advantages and disadvantages of the more naturally suitable site, and an engineered facility in a less naturally suitable site, should be considered. (For example, the use of 20 acres of agricultural land versus the more complex design and high cost of engineering a gravel pit for landfilling.) It is generally more difficult to design and operate a landfill in a marsh land, due to the potential impact on ecology. Landfills generally are not sited in close proximity to shoreline features, particularly near bluffs or high shore banks or on areas subject to storm erosion. Filling of flood-plain areas is not acceptable where this will cause erosion problems and adverse impacts on flood levels. It is, however, the responsibility of the proponents, through sound planning process, to select the site and the site design.

The MOEE considers the most significant adverse environmental effects of a landfill site to be normally within 500 metres of the perimeter of the fill area. Where land use within 500 metres of the fill area is proposed, the developer should evaluate the presence and impact of any adverse environmental effects or risks to health and safety and should undertake necessary remedial measures. This assessment should be based on the nature and knowledge of the disposal site, and nature of land use(s) proposed. The guidelines for land use on or near operating and non-operating landfill sites are provided in MOEE Policy 07-07.

3.3 LANDFILL LEACHATE

a) Leachate Migration and Natural Attenuation

"Leachate" is wastewater containing organic and inorganic compounds, that is produced when water and other liquids seep through the waste deposited at landfill sites. Leachate characteristics and rate of production vary from waste type, site to site and over time. Different landfilling operational conditions (e.g., cover type, thickness and application frequency), age of the landfill (or cell), varying and different degrees of moisture input (e.g., rainfall intensity, duration and frequency), different materials that are landfilled and landfilling of liquid wastes (e.g., sludge), all contribute to produce landfill leachates that are distinctly different from site to site.

Rainfall provides the major transport phase for leaching and contaminant migration from a landfill site. Although some moisture may be derived from the wastes that are being landfilled, the primary precursor to leachate formation is the infiltration from rainfall or snowmelt. Therefore, controlling the amount of infiltration into the refuse has the greatest effect on leachate production. Infiltration can be controlled by carefully selecting cover material, cover slope, final cover and vegetation and by controlling surface drainage. Where waste compaction is regularly and consistently practised, the volume of leachate generated is related to the in-place density of the compacted waste, and generally decreases with increasing compaction of the waste.

In order to understand landfill contaminant movement, it is necessary to understand the mechanisms of contaminant transport which are primarily advection, diffusion and dispersion:

i) advection, which involves contaminant transport along with flowing water (e.g., ground water). The contaminants move at the same rate as the flowing water;

ii) diffusion, which involves movement of contaminants from points of higher chemical concentrations to those of lower chemical concentrations (e.g., movement of contaminants through natural clay deposits or through compacted clay liners; and

iii) dispersion, which involves the mixing and spreading of contaminants within the ground water flow system, and depends on advective velocity, and the characteristics of pore spaces and fractures in granular soils, porous media, or fractured rocks.

As the leachate plume or leachate contaminated water moves away from a waste disposal area, the concentration of contaminants is reduced by the process of "natural attenuation". The degree of natural attenuation achieved depends on the composition of the leachate,

characteristic of the surrounding land (e.g., hydrogeologic and hydrologic conditions down-gradient of the landfill, the existence of a natural barrier, such as clayey deposits, to contaminant migration, ability to undergo physical and chemical processes discussed below), and the availability of buffering space.

Leachate attenuation takes place by the following processes:

Physical and Chemical Processes

- Dilution, which involves the mixing of contaminated water or leachate with uncontaminated or less contaminated water. The degree of dilution achieved depends on a large number of factors including dispersion in the ground water system and the infiltration characteristics of the soil down-gradient of the waste disposal area.

- Volatilization, which is the evaporation of organic liquids or organic constituents which have been dissolved in water;

- Precipitation, which is the removal of contaminants from solution, by forming solid particles, as a result of changing geochemical conditions, (e.g., changes in soil or ground water pH, temperature and alkalinity can result in the precipitation of metals, particularly lead, zinc, iron and chromium);

- Ion exchange, where some of the charged cations (e.g., certain metals) in ground water or leachate displace other cations with lesser ionic charges on contact with clay mineral particles; and

- Adsorption, where dissolved ions in leachate are attracted and adhere to the surface of soil particles through certain physical properties possessed by a particular soil.

Chemical attenuation processes generally involve immobilizing contaminants or replacing one contaminant or salt with another. Immobilization takes place usually with the exchange from liquid phase (where contaminants are in solution) to a solid phase by either precipitation, ion exchange or adsorption.

Biological Process or Biological Decomposition

- The breakdown of organic and inorganic components by bacteria and other micro-organisms is not considered to be significant in the natural attenuation process. Much of the biological activity occurs within or very near the landfill property and therefore, the focus has been more toward leachate treatment when dealing with biological factors.

In general, fine grained soils (e.g., silty clay) are good contaminant attenuators and, coarse grained soils (e.g., sand, gravel) and areas of fractured rock are poor attenuators. Mixes of grain sizes, as occur in the glacial tills in Ontario, are generally good leachate attenuators. Sites with natural clay deposits can provide a natural barrier for restricting the movement of leachate. At such sites, incidents of leachate seepage to the surface occur more frequently than those sites located in more permeable deposits.

The landfill design should include an assessment of the degree of natural attenuation that may be achieved. Although natural attenuation processes are complex, the state-of-the-art has now advanced to a point where predictive analyses can be used as an aid in assessing quantitative and qualitative reductions in contaminant concentrations in leachate as it moves away from waste disposal areas. Predictive analysis should be complemented by a monitoring program and thereby verify and adjust predictions based on actual site data. It is also recognized that it may not be sufficient to rely totally on natural attenuation for leachate management especially for larger landfill sites, due to the large number of physical constraints which can exist. Control measures to contain, collect and treat leachate may be incorporated into the landfill design to supplement the natural attenuation capabilities of such sites.

b) Liner Systems

Engineered facilities designed and installed at landfill sites to restrict or control the movement of leachate usually take the form of physical barriers. Liners are commonly used beneath and on the sides of waste fill area to control the movement of leachate in a downward or lateral direction. Normally, leachate collection system complements the liner system. Examples of liner systems include compacted clay liner, other soil liner, geomembrane liner and cut-off walls. They are discussed in more detail in Subsection 4.10.

c) Leachate Collection System

Leachate collection is a means of controlling the accumulation of leachate and formation of excessive leachate head in the landfill. Particularly where leachate containment is the design basis, leachate collection is essential. Leachate collection system typically consist of perforated collector pipes, embedded in drainage layer(s), which directs the leachate to a common sump pump or pump station. The leachate collection systems can include underdrain systems, perimeter systems, or purge wells. They are discussed in more detail in Subsection 4.10.

d) Hydrogeologic Trap - Landfill

Hydrogeologic trap is a type of landfill design that makes use of inward-moving ground water to prevent the outward movement of leachate. This condition is generally achieved by excavating the landfill below the top of the saturation zone and maintaining the level of the leachate in the landfill below that of the ground water outside of the landfill by pumping. This creates hydrogeologic gradient into the landfill.

This design is most appropriate in the areas where the top of the zone of saturation is relatively close to the ground surface. To avoid handling large volume of ground water, sites are generally located in areas where the materials have relatively low hydraulic conductivity or where the landfill site is lined.

e) Leachate Treatment Systems and Disposal

Leachate may be treated on-site to levels acceptable for discharge into the storm sewer or natural watercourse. Alternatively, leachate can be treated at a water pollution control plant (WPCP), with pre-treatment or possibly without, and by discharge to a sanitary sewer or hauled by vehicle. Municipal and/or MOEE approval is required and care should be taken to ensure that the leachate will not adversely affect the efficient operation of the WPCP. Testing at one WPCP in west-central Ontario indicated that pre-treated leachate that makes up to 2% of the volume of normal municipal wastewater would not have a significant effect on the WPCP performance or on effluent quality. It is necessary to evaluate leachate treatment and disposal schemes with leachate characterization and pilot scale testing. While WPCP performance and effluent quality may be acceptable under current regulations, more stringent treatment requirements may be forthcoming. For example, contaminants in the leachate may not affect plant performance, but may pass-through the plant and, without removal, be discharged in the effluent. Section 53 of the OWRA requires submissions for, and approval of, wastewater treatment systems that discharge to watercourses or water bodies.

Leachate recirculation by injection into a previously landfilled area can be considered as an option for on-site management of the collected leachate. (Spraying over the landfilled area may be possible but only with careful consideration to odour, over-spray and other surface concerns.) Recirculation is a basis for rapid stabilization of the landfill through acceleration of the biodegradation process in the landfill and thereby shortening the time period during which land settlement is most rapid and the landfill produces its most highly contaminated leachate. Production of the landfill gas, a product of waste biodegradation in the landfill, will likely increase, possibly improving the opportunity to recover the landfill gas for energy use.

Leachate recirculation also delays the disposal of leachate by temporarily storing the leachate in the landfill. The quantity of leachate requiring recirculation tends to rise over time due to infiltration of precipitation and, to a lessor degree, ground water seepage into the landfill. It will eventually accumulate to a volume that exceeds the storage capacity of the landfill. As part of the design of the recirculation process, a portion of the collected leachate needs to be disposed of in an appropriate manner.

A concern with leachate recirculation is the added head on the base of landfill, possibly causing an increase in the amount of leachate discharge to the surrounding soil. This concern must be carefully evaluated on a site specific basis.

f) Typical Components in Leachate

Table 1 lists typical characteristics of leachate produced by landfill sites receiving municipal waste. It should be noted that leachate characteristics will vary from one landfill to another. As well, trace organics may be present in the leachate dependant on the characteristics of the wastes deposited in the landfill sites.

Table 2 indicates the predicted trends for various leachate parameters, through the active stage of landfill life and after closure.

Table 3 provides a comparison of leachate characteristics produced from an operating and a closed landfill site.

TABLE 1: Summary of Typical Leachate Characteristics (based on 20 leachate samples from municipal wastes)

Components	Typical Range (ppm where applicable)
pH (no units)	6 - 7
Alkalinity	300 - 2,000
Hardness	400 - 2,000
Chemical Oxygen Demand (COD)	150 - 6,000
Biochemical Oxygen Demand (BOD)	50 - 4,000
Dichromate Oxygen Consumed (DOC)	4 - 500
Total Kjeldahl (TKN)	1 - 100
Ammonia	5 - 100
Nitrate	<1 - 0.5
Nitrite	<1
Sulphate (SO_4)	<1 - 300
Phosphate (PO_4)	1 - 10
Aluminum (Al)	<0.01 - 2
Arsenic (As)	0.01 - 0.04
Barium (Ba)	0.1 - 2
Beryllium (Be)	<0.0005
Boron (B)	0.5 - 10
Bromide (Br)	<1 - 15
Cadmium (Cd)	<0.01
Calcium (Ca)	100 - 1,000
Chloride (Cl)	20 - 2,500
Cobolt (Co)	0.1 - 0.08
Copper (Cu)	<0.008 -1
Chromium (Cr)	<0.010 -0.5
Fluoride (Fl)	5 - 50

Modified From Source:

K.A. Vooro, Chemical Characteristics of Leachate from Ontario Landfill sites, University of Waterloo Work Report, December, 1988

TABLE 2: Anticipated Fate of Leachate Components

Parameter	Predicted Trend With Increasing Time
A. Components that will degrade or properties that will change	
Alkalinity	Decrease
Biochemical Oxygen Demand (BOD)	Decrease - organics to carbon dioxide (CO_2) and methane (CH_4)
Chemical Oxygen Demand (COD)	Decrease - organics to carbon dioxide and methane
N-Nitrate (NO_3)	Decrease - nitrogenous compounds to ammonia (NH_3)
N-Total Kjeldahl (TKN)	Decrease - nitrogenous compounds to ammonia
pH	Increase - towards neutrality
Total Dissolved Solids (TDS)	Decrease
Specific Conductivity	Decrease
Sulphate (SO_4)	Decrease - ultimately to hydrogen sulphide (H_2S)
Volatile Acids (VA)	Decrease - organics to carbon dioxide, and methane
B. Immobilized Compounds	
Iron (Fe)	Decrease (function of pH increase)
Lead (Pb)	Decrease (function of pH increase)
Zinc (Zn)	Decrease (function of pH increase)
C. Compounds with enhanced or unaffected mobility	
Chloride (Cl)	Little change

Source: Report to Congress, Executive Summary, EPA (1977) (1).

TABLE 3: Example of the Trend in Basic Chemical Characteristics of Leachate with Increasing Time - Burns Bog Landfill Vancouver (1976 to 1990)

Parameter	1976 - 'Young' Cell	1990 - 'Older' Cell
	(mean concentration in mg/L where applicable)	
Alkalinity (as $CaC0_3$)	4,110	1,560 (Range 1,238 to 1,920)
BOD_5	13,640	25 (Range 10 to 60)
COD	19,250	325 (Range 175 to 425)
NO_x (Nitrate + Nitrite)	<0.05	8 (Range - to 25)
N - Total Kjeldahl (TKN)	32.0	230 (Range 180 to 300)
N - Total Ammonia	<0.05	200 (Range 170 to 240)
pH	5.2	7.6 (Range 7.3 to 8.0)
Volatile Acids	8,505	Not Available
Total Iron (Fe)	1,225	15 (Range 8 to 30)
Total Zinc (Zn)	39.2	0.3 (Range 0.1 to 0.5)

Source: Mavinic, D. S. - 'Leachate Treatment and Disposal - Research and Development', in Proceedings of PCAO/MOE Leachate Treatment and Disposal Seminar, March, 1991.

3.4 LANDFILL GAS

a) Gas Generation and Movement

Decomposition of organic wastes in landfill sites produce gases that are mostly methane and carbon dioxide. The composition of the landfill gas, for example, can be approximately 50% methane, 40% carbon dioxide, low or trace levels of nitrogen, sulphides, disulphides and organics. Initially, the wastes decompose aerobically producing mainly carbon dioxide. As the oxygen is used up within the filled area, the process proceeds to anaerobic decomposition, where both methane and carbon dioxide are produced. Methane production from the landfilled wastes normally reaches a maximum rate at about two years after placement and may continue at this rate for many years. This depends on the waste characteristics, permeability of the soils, the depth of the waste, the position of the water table and climate. The heat generated from microbial activity maintains the necessary temperature within the landfill (recognized as being above 10°C) for microbial activity to take place even during the winter.

The biological decomposition process results in the generation of landfill gas until some period, likely decades, after landfill site closure. It should be assumed that the production of the landfill gas, in particular methane in potentially hazardous concentrations, will continue indefinitely unless demonstrated to be otherwise.

Landfill gas tends to migrate through waste and surrounding soils by paths that offer the least resistance. Vertical gas movement or venting can be greatly reduced by saturated soils, clay cover, snow and ice. The gas then migrates laterally, under pressure from newly-generated gas. Migration may depend upon:

i) the pressure gradients within the landfill to surrounding soils;
ii) the permeability of soils to the movement of methane; and
iii) the type of materials which bound the refuse area, and their vertical and horizontal juxtaposition.

As the generation of landfill gas and potential migration can vary on a site-specific basis, a gas monitoring program may be necessary on a site-specific basis.

b) Landfill Gas Hazards and Concerns

The common concerns with landfill gas is the potential fire and explosion hazards of methane. Methane is a colourless, odourless, lighter than air, non-toxic and flammable gas. Methane and air mixture containing 5 to 15% methane, by volume, is a highly explosive mixture. Migrating methane gas from a landfill can accumulate in confined places in nearby buildings and structures, creating fire or explosion hazards.

The landfill gas, due to the absence of oxygen, can asphyxiate humans, animals and vegetation. Migrating landfill gas can displace oxygen in the root zone and thereby kill vegetation that provides aesthetic value and erosion control. Vegetation with shallow roots is easily affected. Adequate control or natural ventilation of the landfill gas should be provided in the landfill design to prevent this effect on vegetation. Dying trees can be an indication of uncontrolled gas migration.

The landfill gas can also be a source of odour. Other landfill gas constituents, which are low or trace levels of mostly organics, can be a health concern if allowed to accumulate to elevated levels.

Adjacent land uses may be impacted by landfill gas by their proximity to the landfill site. These land uses include, but not limited to the following:

i) existing, proposed and potential homes;
ii) buildings;
iii) wells;
iv) sewer, gas and water mains;
v) transmission facilities; or
vi) crop lands.

The assessment of the impact of landfill gas on neighbouring land uses may be needed at small landfill sites, while an assessment would probably be needed at larger sites; however, the need for an assessment can be determined only on a site specific basis. An assessment, where undertaken, should include a study of the potential risks of explosion in structures, as well as, the possible vegetation distress associated with oxygen deficient soils where landfill gas migration occurs.

MOEE document, "Guideline for Assessing Methane Hazards from Landfill Sites" and "Appendix A" should be reviewed for additional information.

For landfill sites where the landfill gas emission(s) may exceed MOEE requirements, formal evaluation may be required. In this regard, the "Interim Guide to Estimate and Assess Landfill Air Impacts" is available from the Air Resources Branch of the MOEE. This document outlines procedures to estimate landfill gas emission rate and contaminant concentrations, and to relate source emission to the point of impingement concentrations.

c) Methane Recovery

At large sites, methane is a potentially recoverable, energy-rich, combustible gas. Methane recovery is being undertaken at several large sites in Ontario and elsewhere. Landfill gas with methane concentration of 50% has half the heat value of natural gas. Landfill sites should be

evaluated on a site-specific basis to predict the quantity and quality of landfill gas, to determine if methane recovery is achievable and economical.

d) Gas Control

The most significant aspects of gas migration, control or requirements, through the operational and closed life of landfill sites, are described in Subsection 4.11.

3.5 HYDROGEOLOGICAL EVALUATION AND REPORT

Hydrogeological evaluation of the site and its proximity is necessary. The hydrological conditions are the basis of a site-specific landfill design that is effective in protecting the environment from landfill generated contaminants including leachate. Potential impacts on ground water and surface water within, at and beyond the property boundaries of the landfill site can be predicted. The design of an effective monitoring program to verify the effectiveness of the landfill design is critically dependent upon the hydrogeological conditions. The design of contingency system also depends upon hydrogeological conditions. A report detailing the hydrogeological evaluation must be submitted by the proponent of the landfill in support of the application for a Certificate of Approval under Part V of the EPA.

The following documents provide guidance on various issues and procedures on the hydrogeologic assessment of landfills and should be referred to:

- The MOEE Policy 15-08, "The Incorporation of the Reasonable Use Concept into the Ground Water Management Activities" outlines the Reasonable Use Concept in setting the limits to the level of contaminants in ground water that is acceptable at landfill site property boundaries. All landfill sites, regardless of their design basis (e.g., natural attenuation, engineered facilities), must meet the requirements of this policy.

- The Surface water quality management policies are set in the MOEE publication "Water Management - Goals, Policies, Objectives and Implementation Procedures".

- "Advice to Applicants and to Consultants in Preparing Hydrogeologic Reports for Proposed Landfill Sites".

The scope of hydrogeologic investigations and assessments are judged by the proponent, in conjunction with MOEE staff, on a case-by-case basis. To demonstrate that a site conforms to the MOEE requirements, the proponent should provide an estimate of potential contaminant discharge from the site. The following steps are required to make this estimate:

i) identification of the subsurface unit(s) that must be protected,
ii) identification of the particular contaminant(s) that is of critical concern at the site,
iii) estimation of the maximum impact of the critical contaminant on the subsurface unit(s) identified in i).

Where such calculations indicate that landfill impacts will exceed Reasonable Use criteria, provisions in the landfill design must be made, for example, through larger buffer area or engineered facilities to collect and manage leachate. Even where calculations indicate that the

Reasonable Use criteria can be met, it is necessary to provide for contingency plan for leachate control in the event that the landfill design fails to perform as predicted.

Hydrogeologic investigations are undertaken by studying the geologic conditions and the hydraulic characteristics of the earth materials and ground water systems at the proposed landfill sites. The overall process involves the drilling of holes to examine the properties of the earth materials and the construction of observation wells (e.g., piezometers, standpipes) within the earth materials to measure the hydraulic properties. The observation wells should be sampled as part of the assessment of ground water quality. It is the interpretation of the data from the observation wells and other wells in the area, and the evaluation of all available hydrogeologic information which allows the landfill designer to make appropriate calculations and to assess the types of environmental controls needed.

The hydrogeologic study includes the prediction of where subsurface contaminants will be transported, the rate and extent of their attenuation, and the pathways for the egress of contaminants. While analytical solutions and numerical models provide the tools for predicting the rate of contaminant generation and movement, the accuracy of the prediction depends on the collection of appropriate and representative data.

The contents and level of the detail necessary for the hydrogeologic study are determined on a site specific basis. The data and assessment to be included in the hydrogeologic study include, but are not limited to those listed below.

i) local geology - materials, thicknesses, distribution and variability;

ii) values of horizontal and vertical hydraulic conductivity for the various geologic materials;

iii) effective porosities of the various geologic materials;

iv) evidence of minor structural discontinuities such as joints, fracturing, weathering and their likely influence on values of porosity and hydraulic conductivity;

v) three dimensional ground water flow patterns as defined by fluid potential gradients (hydraulic gradients) and the distribution and hydraulic properties of the earth materials;

vi) existence of major structural features such as fractures and faults;

vii) geochemical retardation characteristics (e.g., absorption capacities of the geologic materials);

viii) proximity to and significance of water resources;

ix) water quality and water level variability of the local hydrologic regime;

x) locations where ground water and surface water from the site discharges to springs and/or streams and anticipated changes in water quality;

xi) discharge policy requirements for bodies of water receiving run-off based on the MOEE's allowable concentrations specified in "Water Management - Goals, Policies, Objectives and Implementation Procedures";

xii) leachate attenuation capability to ensure that boundary limitations pursuant to the MOEE Reasonable Use Concept are not exceeded. Predictions as to the extent and direction of contamination within the property limits should be included using supporting information accumulated during the monitoring period to validate the predictions;

xiii) consideration and design of control works;

xiv) the effect of the control works on the natural hydrogeologic regime; and

xv) monitoring and contingency systems - need and conceptualization.

The assessment of the environmental impact of leachate on water resources requires an adequate understanding of the migration of contaminants in ground water. Mechanisms including advection (flow of ground water), diffusion and hydrodynamic dispersion, act to transport contaminants in ground water. At the same time, mechanisms such as absorption, chemical precipitation, volatilization, biodegradation and matrix diffusion act to attenuate or retard the transport of contaminants.

3.6 MONITORING

Monitoring at landfill sites, in general, involves the inspection, sampling and analysis of ground water, surface water, leachate and landfill gas to ascertain that the site is in conformance to the procedures and environmental standards specified in the Certificate of Approval and the Design and Operations Plan. Routine monitoring should be capable of alerting the site owner/operator to problems or potential problems. The early warning will allow for corrective measures to be taken, thus avoiding or lessening any possible environmental damage. A monitoring program also serves the purpose of providing the general public, directly or through regulatory authorities such as the MOEE, with information on the effectiveness of on-site controls and buffering capability of the landfill site. Details of monitoring programs for ground water, leachate, surface water and landfill gas are discussed in Subsection 4.23.

Based on the site conditions and any established engineered facilities, the migration and concentrations of landfill contaminants can be predicted for the duration of the operation and after closure of the site. Typically for the larger landfill sites, contaminant concentration contours relative to varying age of the site are predicted.

To provide an initial basis for predictions of future contaminant concentrations, the background quality of surface water and ground water in all aquifers in the vicinity of the site are determined by a local sampling program. The program should also test for seasonal variations in water quality due to such operations as road salting and fertilizer use.

Monitoring data, collected through the life of the site, can be compared to the values predicted for landfill contaminants to determine any variance from the predicted environmental impacts. This is an on-going verification of the effectiveness of the design of the landfill site. Comparable values of the collected data and predicted values is also an indication of the validity of the prediction model. Nonetheless, the prediction model should be reassessed on an on-gong basis for improved accuracy as additional information is attained.

The potential environmental concerns of the future may be identified by the prediction model and the trends recognized from the monitoring data collected over the years. The comparison of the predicted values to the environmental standards is a means of verifying the future effectiveness of the landfill site design and should determine whether the site will continue to be in compliance. The early warning of environmental problems may result in remedial actions or the implementation of the Contingency Plan.

3.7 SITE DESIGN AND OPERATIONS PLAN

A site Design and Operations Plan provides a progressive disposal plan, to optimize the use of the valuable landfill resources and to meet regulatory and non-regulatory landfill design and performance criteria.

The site Design and Operations Plan describes, in detail, site preparations, daily operations, environmental control measures, site development, closure, and post-closure monitoring and maintenance. A Contingency Plan outlining remedial measures for implementation in the event of unexpected environmental impacts is included.

A site Design and Operations Plan is prepared by the landfill owner/operator as support document of an application for a Certificate of Approval under Part V of the EPA. The Plan should detail completely all aspects of the design and operation of the landfill. In some cases, the Plan is developed to conceptual level and submitted for approval by the hearing boards or the MOEE. Further details would subsequently be submitted either prior to approval, or as conditions of approval.

Modifications to the site Design and Operations Plan can be made at various stages in the approval process to incorporate progressively increasing levels of knowledge, and to accommodate changes inspired by the public review and the approval process. Following formal approval, modifications to the site Design and Operations Plan require approval of the MOEE.

Contents of Report

The content, level of detail required and the approach to the varying components of the Plan are dependent upon site-specific criteria, such as waste types and quantities, environmental conditions that are present and surrounding land use. The following is a general guide to the contents of the Design and Operations Plan:

a) Summary and Recommendations

i) brief results of the hydrogeological investigation, recommended procedures for site establishment, development, operation, management, maintenance and closure; and
ii) costs.

b) Introduction

i) objectives;
ii) background; and

iii) design approach.

c) Design and Development of a Selected Site

i) Description of Selected Site

- legal descriptions and survey of the land proposed as the location of a landfill site and the specific portion of this land that is to be used for landfilling; and
- description, ownership, tenancy and present uses of the site and adjoining lands. This should include uses permitted by the municipal official plans, restrictive area by-laws and class of farm land where applicable.

ii) Population of Area

- existing population of area to be served;
- projected population during design life; and
- other areas potentially serviceable.

iii) Existing Waste Disposal Facilities

- need for the proposed site in reference to the existing disposal facilities;
- problems with current or anticipated inadequacy of existing facilities; and
- if a site expansion is contemplated, outline necessary changes in disposal practices.

iv) Waste Characteristics

- identify type of wastes which may be deposited;
- project quantities for each type of waste that may be deposited;
- stipulate areas suitable for each type of waste deposition;
- stipulate the type of wastes which are to be excluded from the site; and
- outline anticipated future waste types and quantities.

v) Site Topography, Geology, Soil Conditions, and Climatology

- indicate limitations of topography, soil conditions, geologic conditions and climatic conditions; and
- provide a contour plan of existing topography and surface features including drainage, buildings, utilities, roads, etc.

vi) Site Capacity

- determine the site volumetric capacity (and tonnage) which should be accurate to within +/- 5% (which for large sites, requires computer calculations); and
- define and plot bottom and final contours of the landfill.

vii) Surface Water Hydrology

- nature of surface water channels, permanency and flows;
- protection of surface water in the area, chemical quality and sediment;
- diversion of surface water around the site;
- ditches for on-site run-off; and
- ponds and structures for sediment and flow control.

viii) Ground Water and Hydrogeology

- basic information on the hydrogeology of the site. This may include ground water level and hydraulic conductivity measurements;
- information about surrounding wells and other water-taking operations;
- reasonable use(s) of the ground water in the adjacent lands;
- construction of monitoring wells;
- assessment of potential contaminant flow paths;
- relationship between hydrogeologic features and landfill design in environmental protection; and
- effects of control systems on natural hydrogeologic flow systems and ground water quality.

ix) Degree of Site Isolation

- location of existing and proposed homes, buildings, wells, rail lines, road and road allowances, sewer, gas and water mains, transmission corridors for electricity and telecommunications, pipelines, lakes, ponds, rivers, watercourses, cemeteries, agricultural, park and conservation lands, airports or any other thing which may be impacted by the land disposal operation;
- facilities necessary for aesthetic and noise control, e.g., berms, plantings, buffer area and other measures of isolation; and
- design and construction features to screen operations.

x) Traffic Generated

- existing and proposed traffic patterns for the area; and

- traffic generated due to landfill operation.

xi) Site Development or Improvement

- clearing and grubbing;
- construction of fire barriers;
- construction of screening facilities;
- roads and fencing;
- buildings and utilities; and
- staging or sequencing the development of the disposal area.

d) Operation and Maintenance

i) Method of Operation

- type of filling - trench, area, or combination;
- working face area and cell height;
- construction methods and procedures (specific methods and staging);
- operation of separate area for segregated material (e.g., brush, appliance bodies);
- winter or wet weather operations.

ii) Waste Compaction and Cover

- source and details of daily, intermediate and final cover materials;
- protection of cover material for winter operation;
- refuse deposition and compaction procedures;
- frequency of covering and compaction of cover;
- planning for the use of soil material within the site boundary; and
- progressive application of final cover, top-soiling and re-vegetation.

iii) Site Approaches and Perimeter

- fencing and signs indicating safety requirements, operating authority, traffic flow, hours of work and special disposal areas; and
- maintenance of neutral zone or green belt.

iv) Operational Facilities and Housekeeping Within Site

- portable container at entrance gate;
- attendance shelter, office and communication facilities;
- weigh scale;
- fire protection and fire-fighting facilities;

- if applicable, operation of facilities for recycling, resource recovery and/or household hazardous wastes, reception and shipping; and
- vector and vermin control;
- litter control; and
- other housekeeping procedures.

v) Site Staff

- review of functions;
- assessment of need (number of staff);
- emergency situations; and
- supervision procedures.

vi) Equipment and Maintenance

- type of equipment to be provided for depositing, compacting and covering and for road construction and maintenance;
- arrangement for alternate equipment; and
- storage and maintenance.

vii) Costs

- capital and operational costs, including leachate collection and treatment system, gas control system, maintenance, monitoring costs;
- completion costs (cost of closing out a site).
- contingency cost;

e) Environmental Control Measures

i) Buffer Area

- land set aside for buffer.

ii) Surface Water Control

- maintenance of designed ditches;
- provision for additional ditches as required;
- maintenance of designed grade;
- diversion from disposal faces;
- sedimentation ponds;
- flow maintenance structures;
- control of discharge; and
- water quality monitoring.

iii) Ground Water Control

- volume estimates;
- cut-off trenches;
- french drains;
- under drains;
- collection areas and pumping;
- discharge control; and
- water quality monitoring.

iv) Leachate Collection Treatment, Disposal and Monitoring

- method of collection;
- method(s) of treatment;
- temporary storage;
- maintenance of leachate collection systems;
- method of leachate handling and disposal;
- establishment of suitable monitoring and review procedures; and
- maintenance and protection of observation wells.

v) Gas Monitoring and Control

- determine need by hydrogeologic analysis of unsaturated sediments;
- assess type of control barriers, active, passive or combination;
- assess disposal or gas utilization technologies;
- establish procedures for record maintenance and review; and
- air emissions.

vi) Burning Protocol

- protocol if burning of clean wood and brush is intended.

vii) Repair, Replacement and Maintenance

- program and schedule for repair, replacement and maintenance of environmental control facilities.

viii) Contingency

- action plan in event the landfill site fails to perform to the approved design;
- trigger(s) and protocol for implementation of the approved contingency plan.

ix) Site Closure

- staged completion;
- final cover system design, landscaping, seeding;
- closing procedures;
- vector and vermin control;
- adaptability of site for future needs;
- long-term monitoring of impact;
- long-term maintenance;
- end-use; and
- financial assurance.

f) Plans and Drawings

i) Plans

- location map utilizing a scale of approximately 1:50,000;
- map showing lots and concessions within one full lot and concession of the landfilling site;
- topographic maps at a scale of 1:2,500 with at least one metre contour intervals; and
- working drawings at appropriate scales.
- title, name of project and municipality;
- scale and north direction; and
- name of engineer and date.

ii) Details Required

- Topographic Details

  - a map indicating the lay-out of the landfilling site;
  - legal description of land for future registration of Certificate of Approval on land title;
  - topography before commencement of operation, clearing and grubbing
  - excavated and final design contours;
  - areas from which cover material is to be excavated;
  - existing transportation and communication rights-of-way;
  - existing site access;
  - existing watercourses and bodies of water;
  - existing and proposed utilities;
  - proposed access and on-site roads;
  - existing and proposed structures;

- existing and proposed airports within ten (10) kilometres of the site, and all flight paths within 16 kilometres;
- existing and proposed fencing (includes movable fencing); and
- details of all sampling stations for leachate, ground water, surface water, and gas monitoring systems.

- Geologic Details

  - geologic materials present at the site, such as bedrock, stratigraphy.

- Hydrologic and Hydrogeologic Details

  - drainage control system, including perimeter ditches, discharge points and special devices; and
  - ground water levels, hydraulic conductivity data, direction of flow, etc.

- Other Details

  - name and address of the current registered owner of the property;
  - details of the existing and proposed land uses (plans, restrictive by-laws, etc.) in the proximity of the site boundaries;
  - details of buffer zone;
  - initial and staged development with completion date;
  - the proposed ultimate use of the site including the proposed owner and operator after disposal operations have been completed; and
  - any other information which, in the opinion of the proponent or the MOEE, will assist the public, hearing boards and the MOEE to properly assess and evaluate the environmental impacts of the site.

SECTION 4

SITE DEVELOPMENT, OPERATIONS AND DESIGN FEATURES

4.1 GENERAL

The process of planning and approval for the establishment of landfill sites was discussed in Section 2, while design philosophy and principle considerations in designing landfill sites was discussed in Section 3. Building upon these overviews, Section 4 includes discussion of, including the rationale for, various site development, operational and design features for landfill sites that must be addressed to ensure safe and secure waste disposal facilities. These issues or requirements for landfill sites are the result of the following:

a) regulatory requirements stipulated in Ontario Regulation 347 and the EPA;

b) operational and design features normally required by the MOEE for the approval of the landfill site; and

c) recommended operational and design features, necessary due to site specific conditions, to achieve preferable performance over and above the minimum standards required by regulation.

The Section 4 includes discussions of procedures and practices that are appropriate for landfills of differing sizes, in terms of the population it serves and its site capacity, and by their proximity to nearby land uses. Small sites generally have a designed lifetime capacity of under 40,000 cubic metres and commonly serve populations of less than 1,500 people. Summary tables of typical or examples of operational practices at landfill sites, with considerations for site capacity and distance to sensitive land use, are presented in Subsection 4.25.

It should also be understood by all that **landfill sites must operate in compliance to their respective Certificates of Approval.** Since the site-specific design and operational requirements forming a Certificate of Approval may be over and above regulatory requirements, in certain cases, the terms and conditions of a Certificate may supersede regulations and guidelines.

4.2 LEGAL SURVEY OF THE SITE

4.2.1 Rationale

A legal survey is a process for legal identification of property and its boundaries with adjacent properties. A survey ensures that a legal designation of the landfill is clearly identified and can be registered on title for the protection of the future landowners and occupants. Also, the survey is one aspect of ensuring that landfilling takes place within the boundaries of the approved landfill property.

4.2.2 General Requirements

a) A legal survey is a survey of a property prepared by an Ontario Land Surveyor registered under the Surveyors Act. The survey should be prepared for all lands that are used for landfilling of waste. Crown lands without legal descriptions are the exceptions and general descriptions and plans of the locations are acceptable.

b) Boundaries are set out on the ground so as to enable accurate determination of the location of the site, with reference points from which the boundaries of the waste disposal (fill) areas can be located.

4.2.3 Procedure for Obtaining a Legal Survey

a) A Registered Ontario Land Surveyor should be supplied with a legal description of the property. The legal description is normally obtained from the deed to the property(s), or from the lease agreements.

b) On the basis of the legal description, the surveyor establishes property boundaries, bench marks and reference points and provides a plan of the described property. A copy may be registered in the Land Registry or Land Titles Offices of the respective county, district, or regional or metropolitan municipality.

4.2.4 Legal Survey vs. Site Plan

A site plan is for design and operation rather than legal purposes. The general differences between a site plan and a legal survey are the following:

i) site plan does not have to be prepared by an Ontario Land Surveyor;

ii) site plan shows the general location of boundaries and may not have bench-mark locations;
iii) site plan may or may not show scaled dimensions of property boundaries; and
iv) legal survey generally does not contain information regarding site activities, waste deposition locations, segregation areas, on-site roads, etc.

4.3 REGISTRATION ON TITLE

4.3.1 Rationale

The purpose of registering a Certificate of Approval for a landfill site on the title of property, is to identify lands which have been or are still being used for waste disposal purposes. This will serve to notify members of the general public and future owners and occupants that the land has been used for waste disposal, and that the land may pose a potential hazard as a result of past landfilling activities and flags the need to recognize the special concerns for the purposes of future development . It should be noted that MOEE approval is required for redevelopment/re-use of closed landfill sites.

Registration on title will also assist in future land use planning adjacent to and in the vicinity of the landfill.

4.3.2 General Requirements

a) The Certificate of Approval should be registered on land title for all existing and new landfill sites. For new sites, the Certificate of Approval is normally required to be registered on the title prior to deposition of waste at the landfill site.

b) Registration on the title is not required for landfill sites located on unpatented Crown Land, in which case the users of the Guidance Manual are referred to Ministry of Natural Resources Policy LA2.02.03 for guidance.

c) Registration on title is normally required for a property adjacent to a landfill where a Contaminant Attenuation Zone (see Subsection 4.4.3) has been established.

d) The Certificate of Approval of the site is registered on land title under the Registry Act or the Land Titles Act. The process of registration is carried out at the respective Land Registry or Land Titles Office for a small registration fee.

4.3.3 Registration on Title for Closed or Abandoned Sites

Where landfill associated hazards exist, registration on title may be required even for closed or abandoned sites. Potential hazards associated with landfill sites include:

i) contamination of ground water and surface water,
ii) methane gas production and migration,
iii) leachate (liquid) migration, and

iv) uneven land settling due to waste settling and decomposition.

Where hazards noted above have been identified at abandoned landfill sites, the following measures can be employed by the MOEE Regional Directors:

i) issue a Control Order and require registration on title as in Subsection 4.3.2 above;
ii) encourage the municipality to take appropriate steps with respect to official plans, restricted area (zoning) by-laws, subdivision control and severance control; or
iii) offer advice on remedial measures to property owners.

The local municipal authority may control potential hazards by enforcing municipal by-laws, offering advice on remedial measures to property owners or by the municipal ownership of the property.

4.4 BUFFER AREA

4.4.1 Rationale

A buffer area may be defined as a green belt or neutral zone around a fill area that is contained within the landfill site boundary, as shown on Figure 4.4 (A). The primary intent of a buffer is to provide space around the perimeter of the fill area to be used for the following purposes:

a) Operation and maintenance needs of the site, including construction of site services and facilities, such as access roads, sewers, administrative and maintenance buildings, material storage areas, equipment compounds, leachate and gas control systems, surface water controls, etc.;

b) Installation of monitoring devices to measure ground water quality, hydrogeologic parameters, gas and leachate migration, surface water quality, etc.;

c) Implementation of remedial measures for the collection and treatment of contaminants;

d) Physical separation from adjacent land areas; and

e) Implementation of nuisance control measures to mitigate noise, dust, odour, litter and visual impacts created by the landfill operation.

As a secondary benefit, the subsurface soil of the buffer area can provide natural attenuation of the landfill leachate.

4.4.2 General Requirements

a) Under Regulation 347, Section 11, buffer area is required around the landfill site.

b) The minimum required width of a buffer is 30 metres and may be more depending upon site-specific needs noted above in the Rationale and evaluation of surrounding land uses. MOEE Policy 07-07, "Land Use On or Near Landfills and Dumps" provides guidelines to protect the health, safety, and welfare of residents from the potential adverse environmental effects of landfills by maintaining an adequate buffer area.

4.4.3 Remedial Measures

a) If leachate is found to be migrating off-site beyond the Reasonable Use criteria, assessment of the need for perimeter barrier walls, collection systems, purge wells or other controls may be required. Similarly, gas control systems consisting of active or passive wells or trenches may need to be installed within the buffer zone.

b) Surface water controls that include perimeter ditches, sedimentation ponds, or other systems to control surface water discharge rates or quality may also need to be established.

c) The size of a buffer zone for these purposes is site-specific but generally requires a minimum of 30 metres to allow for construction equipment access during installation of corrective works.

d) The landfill owner can acquire ownership of adjacent lands for attenuation of contaminants and compliance of the Reasonable Use criteria.

e) The Contaminant Attenuation Zone is defined as an area located outside the landfill site boundary, as shown on Figure 4.4 (A), where contaminants will be naturally attenuated to levels compatible with the reasonable use of the adjacent property. The MOEE document entitled "The Incorporation of the Reasonable Use Concept Into the Ground Water Management Activities of the Ministry of the Environment" states that the Reasonable Use Concept will be applied to determine quantitatively the acceptable levels of various contaminants originating from the waste disposal site and impinging on adjacent properties. It further states, that a Contaminant Attenuation Zone may be designated outside of the waste disposal site in exceptional circumstances to attenuate contaminants to acceptable levels. This could be accommodated by means of easements or other restrictions on land use and requires a legal agreement between the owner(s) of the landfill and the owner(s) of the adjacent property on which the Contaminant Attenuation Zone is to be located. The Contaminant Attenuation Zone should be identified in the Official Plan and on zoning maps of the municipality.

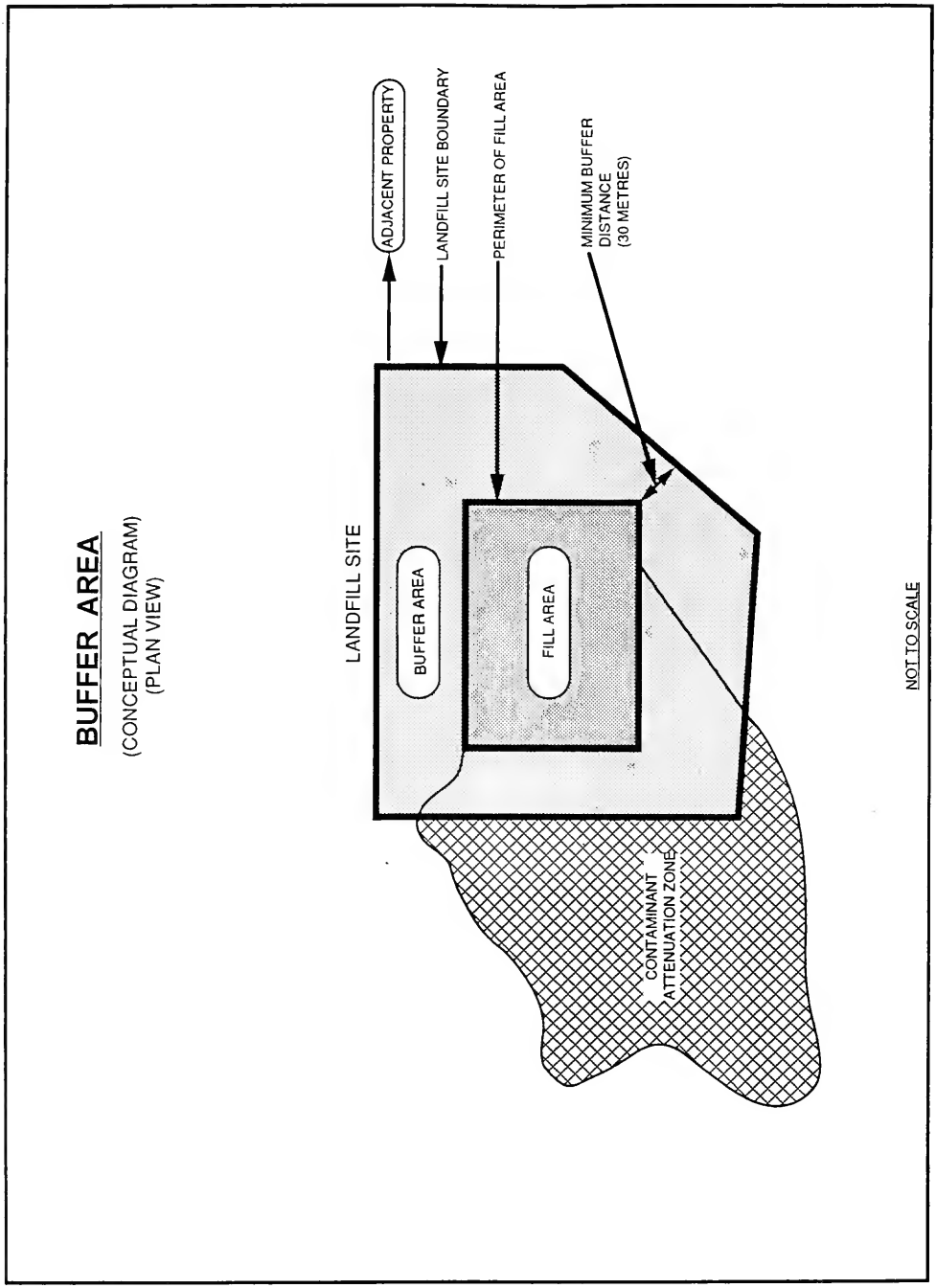

BUFFER AREA
(CONCEPTUAL DIAGRAM)
(PLAN VIEW)
ADJACENT PROPERTY
LANDFILL SITE BOUNDARY
PERIMETER OF FILL AREA
MINIMUM BUFFER DISTANCE (30 METRES)
LANDFILL SITE
BUFFER AREA
FILL AREA
CONTAMINANT ATTENUATION ZONE
NOT TO SCALE

FIGURE 4.4 (A)

4.5 ON-SITE ROADS

4.5.1 Rationale

The intent is to provide a system of on-site roads to allow for safe, orderly and uninterrupted flow of vehicles at the landfill site under all reasonable weather conditions.

4.5.2 General Requirements

Under Regulation 347, Section 11, access roads and on-site roads are required to allow the travel of vehicles hauling waste to and on the landfill site under all normal weather conditions.

4.5.3 Access From Public Roads

a) The site owner/operator should ensure that the public road leading to the landfill site can accommodate landfill traffic with respect to loading restrictions and local by-laws on noise and haulage, without creating a hazard to other users of the road.

b) The intersection of the main access road to the landfill site with an existing public road should be clearly visible, at a safe distance to all users of the public road. and should be designed to minimize any interference with traffic on the public road.

4.5.4 On-Site Road Design and Construction

a) The location of on-site roads requires careful planning in order to avoid relocation in the future, which would result in unnecessary expense and disruption to landfill activities.

b) All on-site roads should be designed and constructed to allow for the smooth flow of traffic, uninterrupted by normal inclement weather.

c) All on-site roads should be designed and constructed to have good drainage and should be structurally stable. Drainage is provided by sloped or crowned road surfaces, cross drains or culverts, and stabilized ditches.

d) The surfaces of all on-site roads should be erosion resistant to the extent possible.

e) On-site roads should be paved or surfaced with gravel, asphalt, cinders or in the manner specified in the approved site design.

f) All on-site roads should have a grade of no more than 10 percent.

g) All on-site roads should have a minimum width as follows:

i) 7 metres for two-way traffic; or
ii) 3 metres for single lane traffic with a recommended pull-off interval of 100 metres or greater if there is an unobstructed view of oncoming vehicles.

In both cases, a one metre (1 m) shoulder should be provided for snow removal and maintenance.

h) On-site roads should be constructed on dry and stable areas. Topsoil should be removed prior to construction of a road and stored on-site taking suitable precautions to prevent erosion of the topsoil.

4.5.5 Maintenance and Operational Considerations

a) Extreme weather conditions, such as unexpectedly heavy snowfall or rainfall, may cause the temporary closure of some or all of the on-site roads. It is the owner/operator's responsibility to ensure that access is restored as soon as practically possible. Contingency plans for such events include the posting of signs at the entrance to the landfill facility and announcements to the public through the media.

b) The site operator should take all necessary measures to avoid delays and line-up of trucks awaiting entry to the site from public roads or access to the disposal area.

c) It is the owner/site operator's responsibility to control access to the landfill and prevent unauthorized vehicular traffic and illegal dumping of waste by providing lockable entrances and/or other necessary barriers at all of the main access roads to the site.

d) The on-site roads should be inspected and maintained to design specifications. This includes inspection for litter, erosion, excess wear and need for dust control. The erosion of the road surface can contribute off-site sedimentation.

e) The owner/operator should inspect vehicles leaving the landfill site to ensure that no landfill debris, mud and waste is transported off the site, and to the extent this is not achieved it shall be the owner/operator's responsibility to remove landfill debris, mud and waste from off-site roadways.

4.6 FENCING

4.6.1 Rationale

Fencing serves many purposes at landfill sites. They include discouraging unauthorized entry, delineation of property boundaries, safety of the public and site personnel, isolating operations when necessary, and for litter control.

4.6.2 General Requirements

Regulation 347, Section 11 requires the waste disposal area to be enclosed to prevent unauthorized entry and roadway entrance(s) to be fitted with lockable gate(s). The use of the landfill is to be restricted to persons authorized to deposit waste in the fill area.

4.6.3 Perimeter and Security Fencing

a) The purpose of perimeter fencing, extending around the entire landfill site, is to control access to the site, such as discouraging unauthorized entry by the public or entry of scavenging animals. It can also delineate the property boundary. To a lesser degree, perimeter fencing can screen landfilling operation, particularly at small, remote sites where topographic features lend themselves to this application.

b) For small sites, hedges, page fences or chain link fences will generally be sufficient. The landfill owner/operator should address the fencing needs on a site-specific basis, taking into consideration isolation, natural topographic relief, vegetation and other natural features.

c) For larger sites, typically a chain link or similar fence (preferably 1.8 metres in height), should be established around the property boundary and where deemed necessary for security purposes. If trespassing and vandalism are potential problems, three strands of barbed wire projecting at a 45° angle may be employed.

d) Within the site, additional security fencing is often employed around heavy equipment compounds, household hazardous waste storage areas, recycling and public drop-off areas, and suspect waste storage areas or outdoor material storage compounds. The use of internal security fencing is generally at the discretion of the site operator.

e) If trees, shrubs, vegetation, or other features enhance the appearance of the site or offer visual screening, noise control or litter control, and if these features would need to be removed or modified for the purpose of constructing fencing, the proponent should

consider the advantages and disadvantages of relocating the fencing in order to preserve the features.

4.6.4 Litter Control Fencing

a) Litter is primarily a public nuisance. Disposal of wastes during high wind conditions often results in paper and other debris being windblown off the working face and sometimes beyond the property boundary. Waste unloading procedures, waste type and preparation, shielding devices, and orientation of the working face relative to wind direction would minimize litter problems. Litter control fences are frequently used to help control this nuisance.

b) Generally, when waste is disposed of in a trench, a 1.5 metre high portable snow fence can be used to capture the majority of wind blown litter. In larger, area-type operations, litter fences up to 3 to 4 metres in height are employed on the downwind side of the working face. Since wind conditions vary from day to day, the litter fences should be movable. In very sensitive areas, permanent litter fences should be provided along critical property boundaries or along the entire property boundary. The extent of perimeter litter fencing will depend on natural topographic relief, vegetation, wind conditions and the proximity of sensitive receptors.

c) Moveable litter fencing should be light weight, sturdy, easily transported around the fill area, and capable of withstanding wind loads that otherwise could either overturn the fence or bend the frame. When designing a moveable or permanent fence of any nature, consideration should be given to wind loadings assuming that the fence's mesh has captured significant quantities of litter and therefore provides a large surface area for wind pressures, resulting in high loads on the frame.

d) To be effective, litter fencing must be kept clear. Once it has clogged, air flow patterns change and litter could be blown over the fence. During operating hours and at the conclusion of each day's operation, or on a regular basis, the landfill operator should make all reasonable efforts to collect all wind blown litter and dispose of it in the landfill.

4.6.5 Other Fencing

During on-site construction, safety fencing should be provided around open excavations or other areas or structures as required in accordance with the Occupational Health and Safety Act, and other applicable regulations.

4.7 SIGNS

4.7.1 Rationale

The intent of placing signs is to provide the public, waste haulers and other users of the landfill site with information and direction regarding disposal of waste, site operation and management and any other pertinent information such as disposal fees, exclusions of specific wastes, on-site operating procedures, and on-site safety procedures.

4.7.2 General Requirements

a) The owner/site operator should provide at least one sign at all public entrances and at all entrances used by waste hauling vehicles.

b) Signs should be posted at prominent locations within the landfill site to direct and control safe operations, and to give warnings of all site hazards, including, but not limited to explosive gases, corrosive liquids, heavy equipment movement, and heavy truck movements. Regulation 347, Section 11, requires signs be posted for the prevention of accidents at the site.

4.7.3 Signs and Information Posting

a) At All Entrances

A large sign, indicating the following information should be provided at all public entrances and at all entrances used by waste haulers:

i) name and address of the site owner and operator;
ii) Certificate of Approval number for operating a landfill site;
iii) hours and days of operation of the landfill site (including time when site is open to public);
iv) admission restrictions;
v) any applicable local municipal by-laws;
vi) emergency contact and telephone number;
vii) types of waste accepted; and
viii) tipping fees schedule.

The ultimate intended site use after closure (if such a plan has been formulated) may be indicated for public awareness purposes.

b) Along Site Access Roads and On-site Roads

Notices on prominent and clearly labelled sign boards, legible at distances of about 20 metres, should be situated along on-site roads conveying the information noted below:

i) direction to users and waste haulers about permitted routes to various disposal areas;
ii) road safety instruction, such as speed limits, intersections, and warnings of other road hazards;
iii) routes on which access is restricted to landfill site personnel; and
iv) warnings on illegal dumping by the side of roads.

c) At Waste Disposal Locations

Information should be displayed prominently on clearly labelled sign boards at all disposal faces and drop-off areas to indicate:

i) type of waste accepted at any particular disposal location;
ii) instructions on disposing of waste at a specific location;
iii) warning of any hazard, such as heavy equipment or truck movement; and
iv) directions on accident prevention and safety procedures specific to a particular disposal location.

d) At Control System Installations

The requirements are specific to each particular installation (i.e., leachate or gas control); however, in general terms the following should be provided by the site operator:

i) warnings on explosive gas hazards and restricted access at all landfill gas extraction wells, at gas monitoring probe locations, valve chambers, maintenance holes, and at exposed riser pipes and vents;
ii) safety procedures and warnings at fan house and equipment installations (manufacturers recommendations should be sought);
iii) warnings of corrosion hazards and restricted access at leachate control and collection systems, such as maintenance holes, leachate sumps, inspection chambers, and purge wells;
iv) safety procedures and warnings at leachate pumping stations and on-site treatment facilities; and
v) no smoking signs at all above locations.

e) At The Landfill Site Office

Access to site offices is normally restricted to landfill site personnel and inspectors from various regulatory authorities. Therefore, public information may not be necessary. However, the following are examples of the information to be provided on signs or on display:

i) safety and emergency procedures governing site staff and site users;
ii) telephone locations and emergency telephone numbers;
iii) fire extinguishing equipment locations and instructions on emergencies concerning outbreak of fire;
iv) operation and maintenance check-lists on major plant and equipment; and
v) spill response procedures and emergency contacts.

Site operators must also comply with the requirements of the Occupational Health and Safety Act of the Ministry of Labour.

f) Monitoring Locations

Identification signs should be posted at all monitoring wells and sampling locations with warnings on restricted access.

4.8 SCREENING

4.8.1 Rationale

The objective of providing measures for on-site screening is to shield landfilling operations from public view. Acceptance of the establishment of a landfill site at a particular location is greatly enhanced if the site is screened from public view naturally, by landscaping or by constructed means.

4.8.2 General Requirements

a) Regulation 347, Section 11 requires the landfill site to be adequately screened from public view.

b) Generally, the landfill site, particularly active fill areas and areas where ancillary operations are in progress, should be screened from public view adjacent to the site. This aspect should be considered early, such as when potential sites are being evaluated for siting the landfill.

c) Screening measures that have to be constructed are expected to be contained within the landfill property boundaries and are usually located in the buffer area. However, under special circumstances, for example when the topography of the sites does not lend itself to the establishment of on-site screening features, off-site screening may be considered. The need for such measures will be determined by the nature of land use adjacent to the site.

d) Landfill sites located in areas where the nearest sensitive land use is at a distance greater than 3 kilometres from the site, generally need to be screened only from the public road leading to the site. The sites with sensitive land use located less than 500 metres away, generally needs to be screened from all sides around the landfill property boundary.

Where the use of the land adjacent to the site changes with the approval of the local municipal authorities, the landfill owner and site operator may be required to establish appropriate screening measures to be determined by the nature of the intended land use adjacent to the site.

4.8.3 Screening Procedures

a) It is recommended that the land space around the fill area be utilized to its maximum potential in providing natural screening of operations. Establishment of the site buffer area and the selection of the landfilling method should take into account the extent of visual screening that should be provided.

b) Tree belts, wood lots, shrubs and other natural land features should be utilized to the maximum in shielding operations from the public view adjacent to the site.

c) Constructed screening berms are frequently used to shield landfill operations from public view. Berms are often constructed with stripped soil from land preparation operations. Excess soil cover material from trench disposal operations is commonly utilized for screening berms. Excavated soil from other landfill operations which is unsuitable for cover application is another source for screening berms.

Soil used for screening berms can be utilized on closure of the landfill site for final cover or as part of a composite final cover system.

d) Fencing and landscaping are other means of providing a measure of screening. Landscaping should be carried out early to provide time for the growth of trees and shrubs before landfilling operations begin at specific locations.

4.9 SURFACE DRAINAGE

4.9.1 Rationale

The intent and purpose of controlling surface drainage at the landfill site is to protect adjacent property and land-users, nearby water-courses, natural drainage paths and sources of water supply from surface run-off influenced by landfill operations.

4.9.2 General Requirements

a) Regulation 347, Section 11 stipulates the following standards for landfill sites:

   i) Drainage passing over and through the site shall not adversely affect adjoining property and natural drainage shall not be obstructed;

   ii) Drainage that may cause pollution shall not. without adequate treatment, be discharged into watercourses; and

   iii) Where there is a possibility of water pollution resulting from the operation of a landfill site, samples shall be taken and tests made, by the owner of the site, to measure the extent of egress of contaminants and, if necessary, measures shall be taken for the collection and treatment of contaminants and for the prevention of water pollution.

b) Surface run-off from a landfill site should not be allowed to have a detrimental environmental impact off-site.

   i) To achieve this, proponents of landfill sites are required to ensure that all surface run-off control facilities and structures are designed and constructed to minimize off-site impacts such as erosion, sedimentation, flooding or contamination.

   ii) In order to minimize suspension of soil in the surface run-off (and subsequent sedimentation), all exposed perimeter berms and stockpiles of soil material should be protected against erosion. Permanent vegetative cover should be established on the outer-face and crown of all perimeter berms as soon as practicable. Stockpiles of soil can be treated with chemical stabilizers or thatching. Where warranted, additional measures such as sediment traps shall be used to complement these measures.

c) Run-off should be diverted away from all active disposal areas.

d) The arrangements made on-site for the control of surface drainage should be designed so as not to interfere with, or obstruct any operation or activity carried out at the landfill site.

e) In the event that any source of water supply in areas surrounding the landfill site is affected through contamination, pollution, interruption or reduction by surface water run-off originating at the landfill site, the owner will be required to restore or replace the affected water supply with an alternative source in sufficient quantity and of acceptable quality for the intended purpose of supply.

4.9.3 Controlling Surface Run-off

a) Run-off Analysis

A run-off analysis is carried out to evaluate variations in the amount and velocity of surface run-off prior to the development of a landfill site, during the operating life of a landfill, and in some cases after closure of the landfill.

Sizing of drainage ditches, diversion structures, impounding structures and discharge structures for larger landfill sites is generally based on a run-off analysis performed by a qualified hydrologist.

Generally, surface drainage structures, ditches and controls are designed to accommodate the 25 years, 24-hour CM (Soil Conservation Service) Type II design storm, which is a rainfall event with a duration and intensity specific to the area where the landfill is located. However, depending on the geology of the site and surroundings, and the proximity to sensitive or important land uses and watercourses, among others, a more stringent control may be necessary and would be decided in consultation with MOEE Regional staff.

b) Site Topography

i) Topography of the landfill site prior to development of the facility, plus interim and final contours for the landfill site during its operating life all determine the design and construction of the surface drainage system.

ii) Surface contours should be designed to control surface run-off, thereby affecting the infiltration of water into operational or completed fill areas.

iii) Interim and final contours of the fill area of a landfill site should have a minimum slope of 5% but not exceeding a maximum slope of 25% (4 horizontal to 1 vertical), unless approved otherwise by the MOEE depending on existing site topography and the site Design and Operations Plan.

c) Diversion Structures

i) Diversion structures include drainage ditches, culverts, storm water catch basins and storm sewers, berms, retention ponds and natural drainage swales. These structures are intended to intercept and convey surface water run-off away from or around active fill areas.

ii) All diversion structures should be capable of accommodating increased storm water flows that accompany a specified storm event. The frequency and duration of the storm event to be considered in the design of diversion structures is to be decided upon in consultation with MOEE Regional staff.

iii) Diversion structures are generally required to serve their intended purpose during the entire active life of a landfill site and also after the closure of a site. In addition, temporary structures will be needed to control and divert surface run-off as filling progresses at the site.

iv) Where the site closure has been designed to minimize infiltration, drainage swales intended to carry surface water run-off over previously filled areas should be lined with impervious clay or a synthetic membrane. The thickness of the clay lining and the specifications of the synthetic membrane will be subject to the approval of MOEE Regional staff.

v) Drainage ditches and swales should be sloped to prevent erosion and to prevent contribution of sediment to streams and off-site drainage ways. Commonly used methods to protect drainage channels from erosion include seeding or sodding of side slopes and bed, stabilization of soil using geotextiles, straw-bale and rock check dams, sod filters, brush filters, stone pitching, and gabion structures.

vi) All diversion structures should be designed and constructed to ensure that intercepted and diverted rainfall run-off does not enter or infiltrate into the leachate collection system or the landfill gas interception system.

d) Discharge Structures

i) The discharge from drainage ditches, culverts and surface water impoundments should not alter or adversely affect the natural drainage pattern of the area surrounding the landfill site property. Discharge of surface water off-site will be permitted only along existing drainage paths capable of accommodating the expected flow volumes, and will require the approval under the OWRA. Analysis should be carried out by a qualified hydrologist to confirm compliance with this requirement.

ii) Discharges from diversion structures, impoundments and other surface water drainage facilities are controlled by energy breaks and concrete or rip rap channels or other devices wherever necessary to minimize erosion, and to prevent deepening, scouring or enlargement of natural watercourses.

Discharge structures depend on specific site conditions and should be designed to standard engineering-design procedures.

4.9.4 Water Quality Protection

a) Treatment Systems

i) Surface water run-off originating at a landfill site may, without adequate control, represent a source of water contamination to surrounding areas. As surface water runs off a landfill site, it may pick up and carry eroded soil, debris, litter, decayed vegetation or trace contaminants. The quality of surface run-off varies widely from site to site.

ii) Provincial Water Quality Objectives have been established by the MOEE to manage, protect and preserve the quality of surface water in the Province of Ontario. These objectives are documented in the MOEE publication titled "Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment", (revised edition of May 1984).

It is the responsibility of the owner/operator of the landfill site to ensure that the objectives as stated by Policy 1 and Policy 2 under the section "Surface Water Quality Management" of the above referred document are met. The established standards for many water quality parameters of surface water suited for most uses in the province have been designated in Table 1 of the same document. Exceptions to these standards are discussed under Policy 2.

iii) In addition to the requirements described above, discharges of surface water into streams and watercourses are regulated by the OWRA, the Fisheries Act of the Federal Department of Fisheries and Oceans and the respective Conservation Authorities, when applicable.

b) Quality Control

i) A majority of the pollutants found in surface run-off from a landfill site are directly related to the suspended solids in run-off water and hence the amount of sediment leaving the site. On-site erosion and sediment control measures significantly reduce the volumes of sediment carried off the site. They are the

main measures adopted for controlling the quality of surface run-off water at landfill sites in the Province. Sedimentation ponds and their function are discussed in subsection **c) Sedimentation Ponds.**

ii) Surface run-off that is intercepted and collected by means of a system of drainage controls (i.e., ditches, berms, impoundments, etc.) may be discharged into a permanent stream or water body, provided that the owner demonstrates to the satisfaction of the MOEE Regional Director that the assimilative capacity (the capacity for dilution or self-purification) of the receiving water body is sufficient to receive the inflow of run-off, in compliance with the following requirements:

- In streams or water bodies having water quality equal to or better than the Provincial Water Quality Objectives, violation of these objectives shall not be permitted; or

- In streams or water bodies with background water quality not meeting the Provincial Water Quality Objectives, no further degradation of water quality in the receiving stream or water body shall be permitted.

Assimilative capacity is determined by carrying out certain site-specific assessments of the receiving water and the discharge from the landfill site, and is usually performed by a qualified water resources engineer or hydrologist.

iii) Upon meeting federal, provincial and municipal regulations, guidelines and by-laws, surface run-off originating at a landfill site may be discharged into the following:

- intermittent streams or watercourses (i.e., watercourses having only seasonal flows);
- drainage swales which form part of an existing natural drainage pattern;
- existing municipal ditch or drain conveying storm water; or
- existing municipal storm sewer.

iv) If the results from the surface water monitoring program indicate unacceptable levels of pollution or contamination in either:

- the surface run-off water at the point of discharge off-site; or
- the receiving streams, water bodies, wells or other sources of water in surrounding areas which have been identified beyond doubt as having been directly affected by the adverse quality of landfill run-off water;

the MOEE may require that suitable treatment measures be carried out prior to discharge off-site and replace/restore the potable water supply.

v) Owners and operators of landfill sites are advised that increasing the time allowed for the settling and removal of suspended solids and sediments (and associated pollutants) and for the die-off of bacteria in sedimentation ponds, will result in the reduction of pollution in receiving or affected water bodies. Monitoring of water quality within a sedimentation pond will indicate the effectiveness, if any, of increasing detention time.

vi) In the worst case, the owner/site operator may be required to transport the collected surface run-off that is highly contaminated to a water pollution control plant.

vii) Small landfill sites may not require any engineered and constructed surface drainage controls provided that the owner demonstrates to the satisfaction of the MOEE Regional Director that the existing topography and geology at the site will effectively prevent:

- surface run-off from entering active fill areas, and from obstructing landfilling operations; and
- surface run-off from causing soil erosion and transporting sediment off-site.

If however, subsequent monitoring indicates that surface run-off from the landfill site has adversely affected the surrounding environment or adjacent land use, the owner/site operator will be required to immediately adopt appropriate control measures as described in the preceding subsections to alleviate the problem to the satisfaction of the MOEE Director. These control measures will then be required to be incorporated into the Design and Operations Plan for the site.

It is the responsibility of the site owner/operator to ensure that the surface drainage control measures adopted are operated and maintained effectively in preventing further adverse impact off-site.

c) Sedimentation Ponds

i) The site owner/operator should provide sedimentation pond(s) for the settlement of silt and sediment that surface run-off would otherwise carry off the landfill property. The sedimentation pond, however, may not be needed if the landfill owner/operator demonstrates to the satisfaction of the MOEE that a

sedimentation pond is not necessary for compliance with the Provincial Water Quality Objectives.

ii) Provision and operation of a sedimentation pond does not relieve the owner/site operator of the responsibility to treat discharge water from the sedimentation pond if necessary to maintain acceptable water quality standards as specified in the Provincial Water Quality Objectives.

iii) The capacity of sedimentation pond(s) should be adequately sized, so as to avoid excessive discharge during the specified high storm event.

iv) The maximum sediment storage volume of the sedimentation pond should be adequately sized such that a reasonable period of time exist between maintenance intervals to restore the sediment storage volume.

v) The outlet of the sedimentation pond should not be located at a lower elevation than the maximum elevation of the sediment storage volume due to the possibility of clogging the outlet with sediment.

vi) Normally, sedimentation ponds are constructed under the supervision of a registered Professional Engineer who can certify to the MOEE that construction was carried out in accordance with the approved design.

d) Monitoring

i) Monitoring of surface run-off is carried out to verify that water quality at the landfill property boundary remains within the approved limits.

ii) Monitoring of surface water should be carried out in accordance with the approved monitoring program as explained under Subsection 4.23. Establishing a sampling program, sampling locations, frequency of sampling, water quality parameters to be monitored, method of analysis and reporting requirements are all discussed in detail under that subsection.

iii) Monitoring of surface run-off after closure of the landfill should be carried out in accordance with a site-specific post-closure monitoring program.

iv) Depending on specific conditions at a landfill site and on the sensitivity or importance of land or water use adjacent to the landfill site, monitoring of water quality within or beneath a sedimentation pond may be required by the MOEE.

4.9.5 Maintenance of Surface Drainage Control Works

a) The Design and Operations Plan for a landfill site should include a detailed program for the maintenance of all on-site surface run-off controls and facilities during the active life of the site.

b) The Closure Plan for the landfill site should include a program for maintenance of surface drainage control works following the closure of the site.

c) The site should be maintained as necessary to prevent erosion or washing of fill, liner or cover material. Regular grading should be carried out to drain rain water from fill areas and to prevent standing water.

d) The site operator should remove debris, wastes and sediment from diversion structures and ditches in order to maintain the design capacity of such facilities.

e) The site operator is required to remove accumulated sediment and silt from sedimentation ponds in accordance with the approved maintenance program. The approved maintenance program should include the frequency and method of clean-out of sedimentation ponds.

f) Sedimentation ponds, temporary diversion structures and other treatment facilities should be maintained as long as necessary.

4.10 LEACHATE MANAGEMENT

4.10.1 Rationale

Control of leachate is required to prevent detrimental effect on off-site ground water and surface water quality or on adjacent land, rendering present uses or foreseeable future uses impractical or unsafe due to migration of leachate.

Leachate is produced when water comes in contact with the waste material and the products of waste decomposition in the landfill. The resulting solution containing water soluble substances is known as leachate. The volume of leachate generated is normally linked strongly to the rate of infiltration of surface water (e.g., rainfall). The design of the final cover, discussed in Subsection 4.22, can therefore greatly affect the leachate generation after the application of the final cover. As well, the design of surface drainage (e.g., diversion of run-off away from fill area) can affect leachate generation rate. As leachate moves in the ground, the concentration of contaminants is reduced or attenuated by natural processes (as discussed in Subsection 3.3). Where natural attenuation is not possible or adequate by itself, engineered facilities are acceptable means of providing protection of the environment.

4.10.2 General Requirements

a) The following are required under Regulation 347, Section 11 for landfill sites:

   i) Landfilling of waste shall be in such manner that impairment of ground water in aquifers is prevented. The landfill shall be sufficiently distant from water supplies, including potable water, so as to prevent contamination of the water, unless adequate provision is made for the collection and treatment of leachate.

   ii) To meet provincial requirements for protection of ground and surface water resources, measures, where necessary, shall be taken for the collection and treatment of landfill contaminants. This includes the construction of berms and dykes of low permeability, if necessary to isolate a landfilling site and effectively prevent the egress of contaminants.

b) Regardless of landfill design (i.e., natural attenuation or engineered facilities), environmental monitoring and contingency plans are necessary at all landfill sites.

c) A Contaminant Attenuation Zone (discussed in Subsection 4.4.3) for the purpose of off-site natural attenuation may be considered in exceptional cases as an alternative to leachate collection. This requires compliance with Reasonable Use criteria, legal

agreement(s) between the affected adjacent property owner(s) and the site owner(s) and approval of the MOEE.

d) The type and extent of engineered facilities, where needed, for the control of leachate is site-specific and will vary depending on parameters such as: amount of buffer, location, stratigraphy, hydrogeology, hydrology and climate; in addition to the quantities and characteristics of wastes deposited at the site. To gain Ministry approval for the use of these materials in the design of a landfill, an applicant must comply with the requirements of Ministry Policy No. 14-15; "Engineered Facilities at Landfills that Receive Municipal and Non-Hazardous Wastes".

Management options include the use of liner systems, collection systems and on-site or off-site treatment or disposal of leachate. Leachate management options are further discussed in this subsection.

4.10.3 Liner Systems

Engineered facilities designed and installed at landfill sites to restrict, or otherwise control, the movement of leachate usually take the form of physical barriers. Liners can be installed beneath and on the sides of waste fill area to control the movement of leachate in a downward or lateral direction or installed in the buffer area to control ground water flow. Normally, leachate collection system complements the liner system. Examples of liner systems include compacted clay liner, other soil liner, geomembrane liner and cut-off walls.

a) Compacted Clay Liner

Clay material is placed on the bottom and sides of the excavated landfill and compacted through controlled procedures. The hydraulic conductivity and optimum moisture content of the clay material to be achieved should be determined. If the hydraulic conductivity is acceptable and if the theoretical impermeability of a re-compacted clay can be reproduced in the field by standard compaction methods, satisfactory performance can be achieved. Although the potential impact of soil-leachate interaction upon the hydraulic conductivity of clay liners has been the subject of recent debate, experience to date suggests that good engineering practice and quality control during construction can result in good quality, compacted clay liners with low hydraulic conductivity. Presently, approximately one meter of compacted clay are often proposed with the intent of achieving, for example, permeability of 10^{-7} centimetres per second.

A particular concern is the potential for clay liner failure resulting from drying, shrinkage or punctures. Proper installation is essential for the clay liner to perform to design specifications. Factors to be considered in the design include the following:

i) nature of the clay itself, including its mineralogy (structural and micro-structural arrangements);

ii) compaction technique, clay moisture content, sub-base conditions and the resultant hydraulic conductivity;

iii) whether or not drying out will occur;

iv) types of waste and leachate composition. Some very concentrated organic wastes may increase the hydraulic conductivity of the clay. Careful consideration should be given in such cases to the clay-leachate compatibility in selecting the liner material;

v) performance characteristics with respect to

- reducing leachate discharge i.e., the amounts of leachate which will pass through the liner or be collected above it,
- reducing ground water inflow to the landfill,
- attenuation of contaminants, and
- diffusion of contaminants through the liner.

Earth liners, other than clay, may consist of fine textured local soil with low permeability, or soil mixed with special clay such as bentonite. Sites have been constructed with bottom liners comprising a 100 to 150 millimetre thick fine sand-bentonite mix. This type of liner requires the same level of effort to design, test, produce and construct as clay liners. Special precautions, taken during base preparation are needed to prevent cracking and settling. It is important to evaluate the extent of possible changes in a liner's physical properties due to chemical interaction with leachate.

b) Geosynthetic Liner System

Geosynthetics are synthetic materials that can be used in the landfill design/construction as an alternative to or in conjunction with natural materials such as clay, sand or gravel. Geosynthetic materials are used where sufficient natural materials, particularly low permeability clay, are not easily or economically available or, where pollution control requirements warrant stringent leachate containment and collection, to enhance the engineering properties of natural materials.

The purpose of a geosynthetic liner system at a landfill site is typically to control the migration of leachate from the fill area to the surrounding soil. An important component of the geosynthetic liner system is the geomembrane liner which acts a barrier, preventing or greatly reducing the migration of the leachate to the surrounding

area. Other components of the geosynthetic system can include geotextiles or geonets. To prevent accumulation of leachate and formation of excessive leachate head in the landfill, a leachate drainage and collection measures are normally incorporated.

Geomembrane Liners

Geomembrane liners are thin (e.g., few millimetres), relatively impermeable sheets of flexible polymeric materials, predominantly thermoplastics. It is also referred to as flexible membrane liner(FML). The primary function of a geomembrane liner in the design of a landfill is to inhibit the migration of leachate into the surrounding environment.

A geomembrane liner may be included as a component of the geosynthetic liner system to augment or replace a layer of low permeability soil depending on the site specific conditions, including the hydrogeologic setting, the estimated contaminating lifespan of the landfill and the economical availability of low permeability soils.

Considerations in the selection of a geomembrane liner include material composition, thickness, construction (fabric-reinforced or not reinforced), desired mechanical properties, sensitivity to temperature, susceptibility to creep under stress, effect of multi-axial straining, permeability to gases, water and organic liquids, sensitivity to organic liquids, stress cracking and fatigue under stress, and long term durability of polymers in waste containment environments. It is also important to consider the combined effect of these properties in the evaluation of geomembrane liner.

Other considerations include thermal effects such as wrinkling or stretching due to differences between ambient temperature during installation and service temperature, the effect of horizontal seams on slopes and at the toe of slopes and liner penetrations for services such as leachate and gas collection pipelines.

Geomembrane liners are generally looked upon as being non-porous materials, however, they contain interstitial spaces between the polymeric molecules through which small contaminant molecules can diffuse.

An example of a geomembrane liner material is high-density polyethylene (HDPE). Its use is popular because it has good chemical resistance to leachate, good strength characteristics, good flexibility and it performs well at low temperatures. Disadvantages of HDPE include poor workability due to its high density, low frictional characteristics, high coefficient of thermal expansion and sensitivity to stress cracking, particularly on the seams. Variations of HDPE are currently being investigated to eliminate the negative features, while maintaining the positive features.

Large geomembrane sheets are transported to the job site for installation which involves placement, seaming and testing. Extreme care must be exercised to avoid punctures, rips or poor seams as they will reduce the effectiveness of the geomembrane liner. As with clay liner construction, quality assurance/quality control is extremely important to ensure proper installation and performances of the geomembrane liner. Defective or damaged liners are difficult and expensive to repair once landfilling has commenced.

A well designed leak detection and monitoring system should be provided for the liner, as well as a viable contingency plan to be carried out if the liner does not perform as designed, based on the monitoring results.

Geotextiles

Geotextiles consist of synthetic fibres, such as polypropylene or polyester, which are woven or matted together in a random non-woven manner, forming a flexible, porous fabric. They are porous to water flow across their manufactured plane.

Geotextiles are used in landfill design for filtration, protection and separation. Geotextiles are used as filters to replace graded granular filters. The geotextile can be used to wrap a leachate collection system allowing leachate to enter the system. A geotextile can also be used as a filter adjacent to a geonet or a sand or gravel layer. The geotextile allows leachate to enter the drainage layer (geonet or aggregate) while preventing fines from entering and clogging the drainage layer.

Geotextiles can be placed below a geomembrane liner to act as a cushion to resist puncture damage to the geomembrane by sharp protrusions in the subgrade (e.g., sharp-edged rocks). Geotextiles can also be placed above a geomembrane liner to resist puncture of the geomembrane by drainage aggregate or waste materials.

Geotextiles can be placed between difference layers of a liner or cover to separate and prevent intermixing of two soil types or soil and waste.

Geonets

Geonets have a net-like configuration of intersecting ribs. Geonets are used at landfills for drainage and are designed to augment or replace conventional materials such as sand and gravel. A geonet can be used as a component of a geosynthetic liner system for leachate drainage, thereby aiding leachate collection. A geonet can also be used as a component of a final cover system to drain surface water.

Geogrids

Geogrids are relatively stiff plastic materials with a grid configuration and large openings. They are often stretched in one or two directions to improve their physical properties. Geogrids are used in landfill design to stabilize and reinforce side slopes, access ramps, perimeter berms and interior berms.

c) Cut-off Wall

Cut-off walls are used to limit leachate migration from existing or closed landfill sites that have not been adequately designed. By constructing cut-off walls around a landfill or down-gradient of the dominant pathway for migrating leachate, it is possible, by reducing ground water flow locally, to lower the rate of contaminant transport by advection and dispersion. Although there may be some diffusion of contaminant, the impact on off-site ground water quality can normally be reduced substantially if cut-off walls are installed. Examples include slurry walls, sheet piling and grout curtains.

4.10.4 Collection Systems

Leachate collection systems are installed to collect leachate in order to prevent accumulation of leachate and formation of excessive head of leachate in the landfill or to collect ground water contaminated with leachate. Typically, a liner system is installed to contain or otherwise control the movement of leachate.

a) Underdrain Systems

The underdrain system generally consist of a series of regularly spaced perforated pipes, typically 100 to 150 millimetres in diameter, embedded in a drainage layer, typically coarse aggregate. The underdrain system is installed at the bottom of the landfill, above any liner system, to collect and remove leachate from the landfill. The leachate is then directed to a common sump or pump station (Figure 4.10 (G)) and collected for treatment or disposal. Figures 4.10 (A) and (B) illustrate an underdrain system.

The perforated piping system should be designed to withstand the weight of wastes and cover material to be placed above it. It should also be capable of resisting chemical attack from compounds and elements contained in the leachate. French drains would be an alternative to, or supplement to, the perforated pipe system. A filter fabric or graded granular filter could be employed to reduce the percolation of fines into the course aggregate above the perforated pipes or within the french drains and collection trenches.

b) Perimeter Control Systems

Interceptor Trench

Interceptor trenches comprise a perforated drain pipe embedded in free draining stone installed along the perimeter of the landfill, in the buffer zone. It is generally considered to be an effective means of intercepting leachate migrating out of the landfill into the surrounding environment. Implementation of such a system may be effective, depending on the depth of installation, soil conditions, length of trench to be installed, and other physical factors. Figure 4.10 (C) illustrates an interceptor trench.

One drawback of this type of system might be the collection of uncontaminated ground water in addition to leachate, resulting in excessive liquid quantities and consequently, increased operating costs.

Toe Drain

Toe drains are installed to control surface breakouts of leachate. The drains are comprised of perforated pipes embedded in free draining stone, installed at the edge of the landfill, either within the fill area prior to the deposition of waste, or alternatively, in the buffer zone once wastes are in place and leachate control is required. Installation depths are generally limited to 5 metres. Figure 4.10 (D) illustrates toe drain systems.

Purge Wells

As an alternative to the interceptor trench, purge wells should be considered. These consist of wells drilled to appropriate depths, equipped with dedicated pumps, to allow pumping down of the water table or leachate level, to promote flow towards the well. The number of wells required is a function of soil stratigraphy and permeability, the quantity of water to be collected and the size of the landfill. Plugging of well screens and other maintenance problems may result in high operating and maintenance costs. Figure 4.10 (E) illustrates a purge well.

Purge well systems installed without the use of barrier walls or other containment method at the site perimeter, could collect uncontaminated ground water, as well as leachate, which would increase the operating costs for the system. Purge wells can also interfere with local streams or nearby ground water users.

c) Impermeable Barrier and Collection System

Leachate collection may be enhanced through the installation of an impermeable barrier placed between the property line and the refuse. The barrier would limit the intrusion of ground water from off-site, thereby limiting the quantity of leachate collected while

at the same time containing the landfill leachate on-site. A collection system comprised of either purge wells or a system of perforated drain pipes would then be installed between the landfill and the barrier wall. The intent would be to maintain water levels down-gradient, outside of the barrier wall, at higher levels than within the site, to promote flow towards the site.

d) Maintenance

Clogging of leachate collection system is a major problem at landfill sites. Sediment or other fine grained materials from the landfill and adjacent soils may be transported with the leachate and deposited in the leachate collection system. In addition, biological growth may clog components of the leachate collection system.

Accordingly, regular maintenance of the collection system is required and should be undertaken at least on an annual basis. Routine access to the collection system should be provided through regular interval of maintenance holes or otherwise so that flushing and cleaning of the collection pipes can be achieved. The maintenance holes also provides access for monitoring of leachate levels and contingency access to allow pumping in case of failure of other system components. Figure 4.10 (F) illustrates a maintenance hole.

e) Temporary Storage Facility

Temporary storage of collected leachate or contaminated water may be necessary prior to treatment or off-site disposal (by tanker truck).

4.10.5 Treatment at Water Pollution Control Plant

a) The collected leachate can be treated/disposed of at an off-site Water Pollution Control Plant (WPCP). This may be accomplished through discharge into the sanitary sewer system leading to the WPCP or transport via tanker trucks.

b) Where the leachate is hauled by vehicle off-site for treatment or disposal, generator registration and manifesting is required pursuant to Regulation 347.

c) The discharge of leachate to the sanitary sewers is subject to the requirements of the local municipal sanitary sewer use by-laws. Additionally, sewer discharge of hazardous leachate requires registration with the MOEE pursuant to Regulation 347.

d) Prior to treatment/disposal at a WPCP, an assessment of the impact, in terms of leachate quality and capacity of the WPCP to handle the increased flows, is normally required. Where discharge to sanitary sewer is involved, assessment of the impact on the

receiving sewer system is also necessary. The impact assessment(s) will determine acceptance/rejection, need for pretreatment and prevent any interruption of the operation of the WPCP. Leachate that is collected and sent to a WPCP should be characterized twice a year using a full suite of organic constituents found in the regulation for Effluent Monitoring Regulation - General under the analytical test groups 1 to 27.

Site design should set aside land and otherwise facilitate installation of leachate pre-treatment facilities if they become necessary to meet sewer use by-laws or to meet conditions for acceptance at WPCP.

4.10.6 Model Sewer Use By-Law

In August, 1988 a "Model By-Law To Control Waste Discharges To Municipal Sewers" was prepared by a committee representing the Ontario MOEE, Environment Canada, and the Ontario Municipal Engineers Association. That document is part of the interim strategy of the sewer use control program and provides a mechanism for the control of toxic discharges to the sewer system. The model by-law is intended as a proposed standard which municipalities could wholly or selectively adopt as their local sewer use by-law.

The following is a partial excerpt from the Model By-Law detailing the proposed discharge limitations to sanitary and combined sewers.

"No person shall discharge or deposit or cause or permit the discharge or deposit of matter of a kind listed below into.....any sanitary sewer or combined sewer:

1. matter of any type or at any temperature or in any quantity which may be or may become a health or safety hazard.....;
2a. solid or viscous substances in quantities or of such size as to be capable of causing obstruction to the flow in a sewer.....;
2b. sewage that may cause an offensive odour....;
2c. .....water from drainage from roofs..... or uncontaminated water;
2e. sewage or uncontaminated water at a temperature greater than 65 degrees C.;
2f. sewage having a pH less than 5.5 or greater than 9.5;
2g. sewage containing more than 15 milligrams per litre of solvent extractable matter of mineral or synthetic origin;
2h. sewage containing more than 150 milligrams per litre of solvent extractable matter of animal or vegetable origin;
2i. .... BOD exceeds 300 milligrams/litre;
2j. .... more than 350 milligrams/litre of suspended solids;
2k. .... more than 10 milligrams/litre of phosphorous;
2l. ... more than 100 milligrams/litre of Kjeldahl nitrogen;
2m. ... 1 milligram/litre of phenolic compounds;

2n. Sewage which consists of two or more separate liquid layers;

2o. Sewage containing dyes or colouring materials....; and

2p. Sewage containing any of the following in excess of the indicated concentrations

1500 milligrams/litre
Chlorides expressed as Cl
Sulphates expressed as SO_4

50 milligrams/litre
Aluminium expressed as Al
Iron expressed as Fe

10 milligrams/litre
Fluorides expressed as F

5 Milligrams/litre
Antimony expressed as Sb
Bismuth expressed as Bi
Chromium expressed as Cr
Cobalt expressed as Co
Lead expressed as Pb
Manganese expressed as Mn
Molybdenum expressed as Mo
Selenium expressed as Se
Silver expressed as Ag
Tin expressed as Sn
Titanium expressed as Ti
Vanadium expressed as V

3 milligrams/litre
Copper expressed as Cu
Nickel expressed as Ni
Zinc expressed as Zn

2 milligrams/litre
Cyanide (total) expressed as CN

1 milligram/litre
Arsenic expressed as
Cadmium expressed as Cd

0.1 milligrams/litre
Mercury expressed as Hg

2q. The following materials or sewage containing any of the following in any amount: Fuels, PCBs, Pesticides, Severely Toxic Materials, Waste Radioactive Materials.

2r. The following materials or sewage containing any of the following in any amount: Hauled Sewage, Waste Disposal Site Leachate (unless approved pursuant to a Certificate of Approval or order which expressly permits discharge).

2s. The following hazardous wastes in any amount: Acute Hazardous Waste Chemicals, Hazardous Industrial Wastes, Hazardous Waste Chemicals, Ignitable, Pathological, PCB or Reactive Wastes".

4.10.7 Monitoring and Reporting For Effluent Discharge

Monitoring and reporting requirements for direct discharge sectors are specified under Effluent Monitoring Regulation - General, issued under the EPA. It provides the technical and scientific methodologies for monitoring which are applicable to all direct discharges. In particular, the regulation specifies the principles of sampling, analysis, flow measurement, and procedures for toxicity testing. The regulation also states the two types of reporting requirements that industry must follow. An initial report is required to provide background information, and subsequently, monitoring reports are required at regular intervals detailing analytical test results and flow measurement data. It has not, as yet, been established if the monitoring and reporting regulation will apply to indirect discharges (including landfill leachate). At this time it is recommended that the above regulation be used as a guide for sampling and analysis of leachate.

4.10.8 OWRA Approval

a) Generally, EPA, Part V approval is required for all aspects of leachate management, including the liner system, collection system and on-site treatment facilities.

b) Where a landfill site involves the ultimate discharge of wastewater, which includes surface drainage and leachate (treated), to the surface water, approval of the treatment works, under Section 53 of the OWRA, by the MOEE Approvals Branch Director is required prior to construction or installation. If the treatment works are exempted by Section 53(6) of the OWRA, then the treatment works must be approved under Part V of the EPA. For example, Section 53 of the OWRA does not apply to a privately owned landfill sites with treatment works designed for the collection and partial treatment of leachate that is to drain or be discharged into a sanitary sewer. Approval of these works are required under Part V of the EPA. If, however, the same treatment works were located at a municipally owned landfill site then approval of these works would be required under Section 53 of the OWRA.

Some of the more common scenarios for the disposal of the collected leachate which require OWRA approval are as follows:

- The leachate from a municipally owned landfill site is transmitted off-site via a sewer (gravity and/or forcemain) which connects to an existing sanitary sewer system;

- The leachate is spray-irrigated onto the surface of the ground in those portions of a site that have been closed and covered or never used for waste disposal;

- The leachate is pre-treated in aerated lagoons (on-site) and seasonally discharged into a local water course or onto the ground surface, or discharged into a sanitary sewer (the latter does not apply to sewage works at a privately-owned site); and

- The leachate is fully treated in a on-site treatment plant and ultimately discharged into a local watercourse or onto the ground surface.

Note: Recirculation of collected leachate back into a landfill requires approval under Part V of the EPA.

4.10.9 On-Site Leachate Treatment

The need for or the degree of on-site leachate treatment depends on the disposal method selected. For example, extensive treatment would be required prior to leachate discharge to a surface water, whereas relatively less treatment may be required prior to sewer discharge to a WPCP. On-site leachate treatment options range from simple treatment such as recirculation or evaporation ponds, to the establishment of complex biological, physical or chemical processes.

a) Leachate recirculation consists of collecting leachate and redistributing it back into the wastes. This could be accomplished through injection wells, buried piping systems, spray irrigation or lagoons with careful consideration to odour, over-spray and other surface concerns. A certain amount of leachate treatment may be accomplished through recirculation back into the wastes. The quantity of leachate in the landfill, theoretically, would continue to increase until it is no longer manageable. Ultimately, leachate removal from the site would still be necessary.

   Recirculation is a basis for rapid stabilization of the landfill through acceleration of the biodegradation processes in the landfill and thereby shortening the time period during which land settlement is most rapid and the landfill produces its most highly contaminated leachate. Production of the landfill gas, a product of waste biodegradation in the landfill, will likely increase, possibly improving the opportunity to recover the landfill gas for energy use. There is, however, a concern that leachate recirculation will create added head on the base of the landfill, which could potentially cause an increase in the amount of leachate discharge to the surrounding soils.

b) On-site leachate treatment facility must be site-specifically designed. Consideration must be given to the quantity and characteristics of the leachate and its variation over time. Leachate characterization and treatability studies should be carried out to determine the design criteria and the most appropriate treatment processes that should

be implemented. Key indicators of leachate treatability and characteristics are the ratio of BOD(5):COD, and the total nitrogen(N) and carbon(C) concentrations.

d) Leachate treatment processes can be broadly classified as biological and physical/chemical processes.

Biological treatment options include the following:

i) Activated sludge processes, where wastewater is exposed to micro-organisms in an aerated basin to breakdown and remove organic matter from the wastewater;

ii) Aerated stabilization basins, which offer a lower degree of process control but also remove organic matter similarly to the activated sludge process. This system requires a large amount of land;

iii) Fixed film processes such as trickling filters and rotating biological contactors(RBC); and

iv) Anaerobic processes.

It should be noted that the effectiveness of biological systems are generally reduced in cold temperatures.

Physical treatment processes generally involve further concentrating the leachate. *Chemical treatment* processes use heat or addition of chemicals to alter the composition of the leachate. These processes include the following:

i) Sedimentation, floatation and filtration technologies where solids are separated from the liquids;

ii) Absorption processes which remove organic constituents from the leachate;

iii) Adsorption processes such as activated carbon treatment, where leachate is passed through a carbon bed and organic chemicals are removed by the carbon granules;

iv) Membrane processes including reverse osmosis, micro-filtration, ultrafiltration, dialysis and electrodialysis;

v) pH adjustment and precipitation, which is used to remove metals such as arsenic, calcium, cadmium, iron, lead, mercury, nickel and zinc, and other chemical compounds; and

vi) Oxidation and reduction, where chemicals are added to a waste stream to oxidize or chemically reduce organic compounds to decrease toxicity or facilitate precipitation.

e) Leachate characteristic varies with time. Current technology provides effective methods of treating leachates that are considered to be 'young' or 'moderately matured'. These are typically produced by landfills at early stages of active life (typically 0 to 6 years), and at an interim stage of active life (typically about 6 to 15 years). respectively.

i) "Young" leachates are characterized usually by high carbonaceous(C) and low total nitrogen(N) composition, or high carbonaceous(C) and low (ammonia) nitrogen(N) composition.

Conventional biological treatment systems are found to be effective in treating such leachates, which are easily biodegradable, and full scale facilities are currently being operated successfully in the province of Ontario.

ii) "Moderately mature" leachates are characterized by low carbonaceous(C) and high (ammonia) nitrogen(N) composition. They have continued to pose problems in the development of effective treatment methods. Most of the current research and development in Canada for their treatment is still at the stage of lab scale or pilot scale testing. It should be noted that data are not sufficiently available to characterize "mature" leachate.

With nitrification as one of the main objectives, some of the possible treatment processes include the following:

- Collect and recirculate back to landfill - this has limited success and treatment is still an ultimate necessity;

- Collection and disposal to local sanitary sewer system, to be conveyed to and treated at WPCP - in terms of ultimate treatment this is not effective as generally nitrogen will not be removed at the treatment plant, but will continue to be present in the final effluent;

- Treatment for nitrification with rotating biological contactors followed by specific polishing techniques has been employed at full scale facilities successfully in Japan;

- Aerobic lagoons - nitrification generally is not complete and only partial ammonia nitrogen removal takes place;

- Aerobic lagoon treatment with the addition of supplemental carbon (methanol is a good source of carbon, glucose is not) - this technique has been tested with limited success due to the large amount of carbon required (carbon to ammonia nitrogen ratio as high as 20:1 is needed);

- Pretreatment with air stripping, followed by aerobic lagoon nitrification has been tested with reasonable success at pilot scale facilities; and

- The latest research and development is being focused on a combination of nitrification and de-nitrification processes.

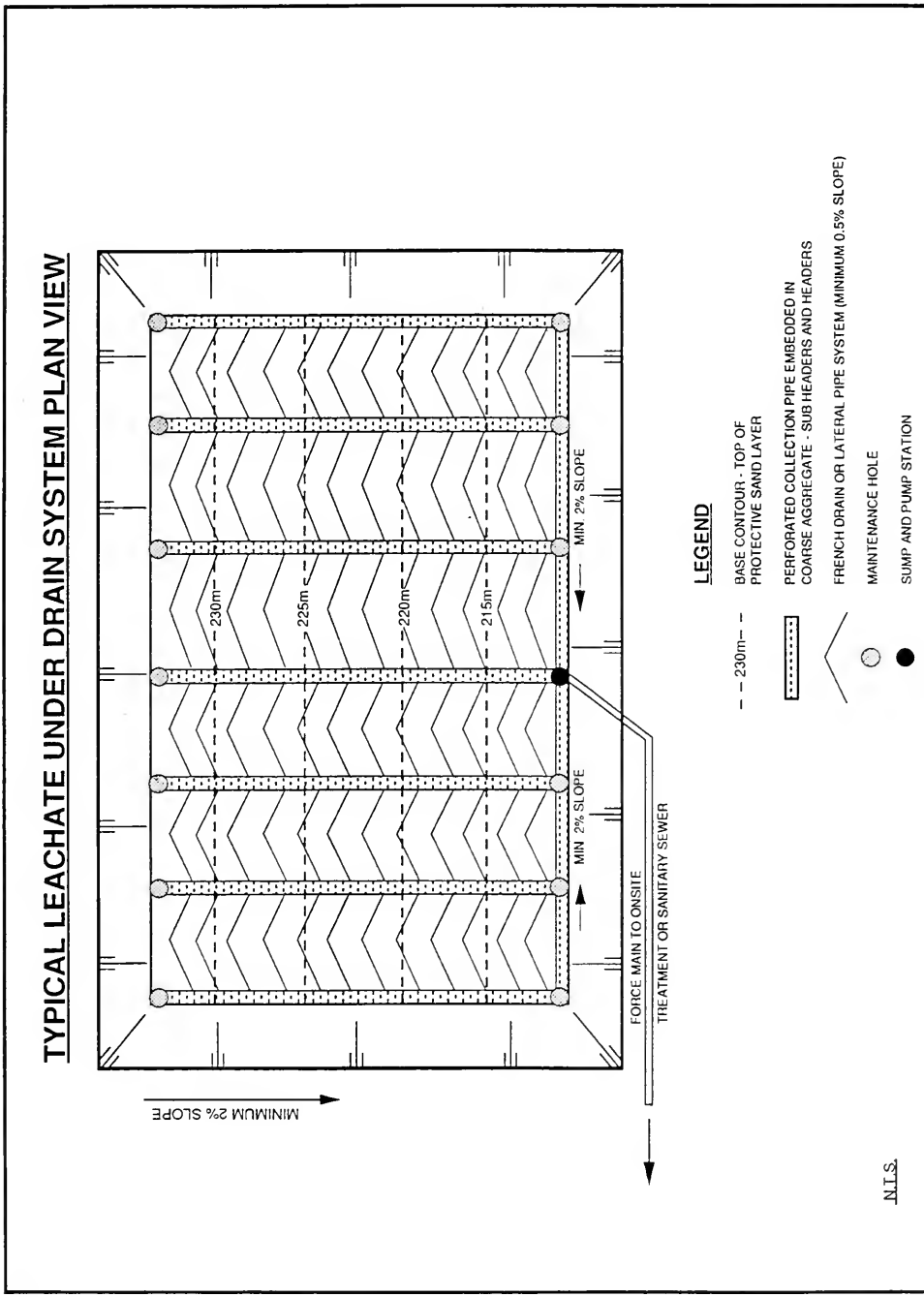
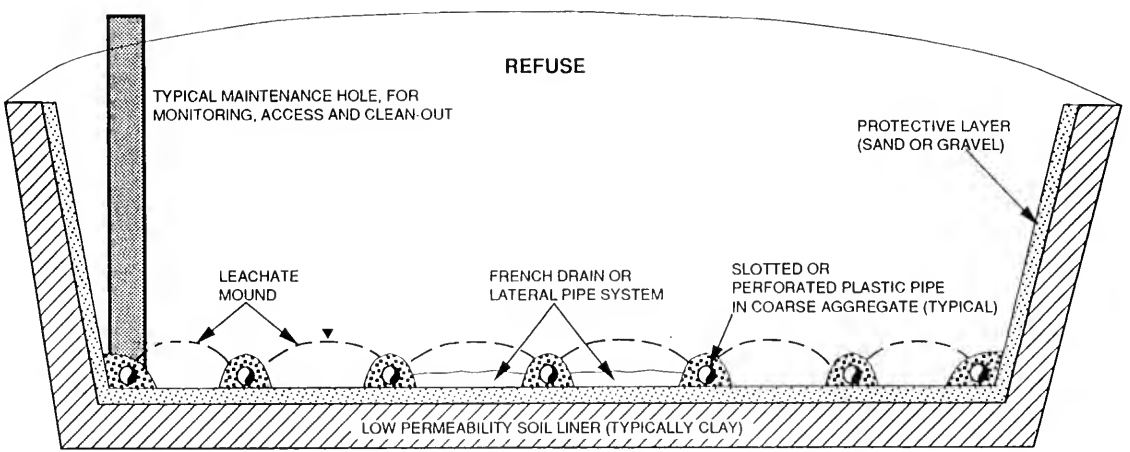

TYPICAL LEACHATE UNDER DRAIN SYSTEM PLAN VIEW
230m
225m
220m
215m
MIN 2% SLOPE
MIN 2% SLOPE
FORCE MAIN TO ONSITE
TREATMENT OR SANITARY SEWER
MINIMUM 2% SLOPE
LEGEND
- - 230m - - BASE CONTOUR - TOP OF PROTECTIVE SAND LAYER
PERFORATED COLLECTION PIPE EMBEDDED IN COARSE AGGREGATE - SUB HEADERS AND HEADERS
FRENCH DRAIN OR LATERAL PIPE SYSTEM (MINIMUM 0.5% SLOPE)
MAINTENANCE HOLE
SUMP AND PUMP STATION
N.T.S.

FIGURE 4.10 (A)

TYPICAL CROSS-SECTION OF LEACHATE UNDERDRAIN SYSTEM ABOVE CLAY LINER



CROSS-SECTION THROUGH LINER AND COLLECTION SYSTEM

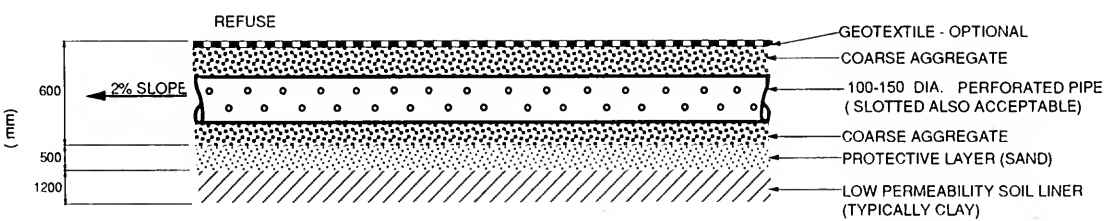


FIGURE 4.10 (B)

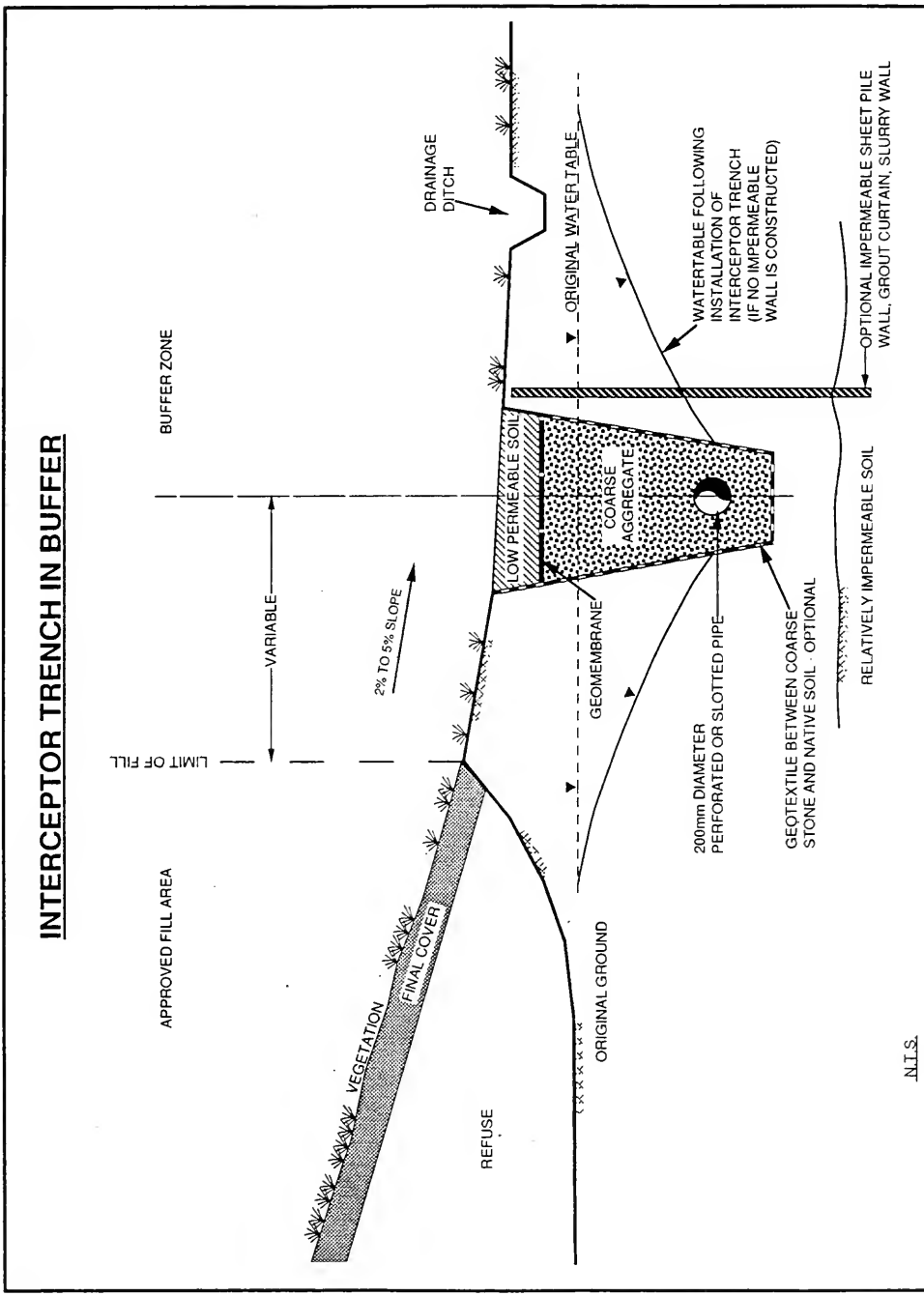

INTERCEPTOR TRENCH IN BUFFER
BUFFER ZONE
DRAINAGE DITCH
ORIGINAL WATER TABLE
WATERTABLE FOLLOWING INSTALLATION OF INTERCEPTOR TRENCH (IF NO IMPERMEABLE WALL IS CONSTRUCTED)
OPTIONAL IMPERMEABLE SHEET PILE WALL, GROUT CURTAIN, SLURRY WALL
LOW PERMEABLE SOIL
COARSE AGGREGATE
VARIABLE
2% TO 5% SLOPE
LIMIT OF FILL
GEOMEMBRANE
200mm DIAMETER PERFORATED OR SLOTTED PIPE
GEOTEXTILE BETWEEN COARSE STONE AND NATIVE SOIL - OPTIONAL
RELATIVELY IMPERMEABLE SOIL
APPROVED FILL AREA
VEGETATION
FINAL COVER
REFUSE
ORIGINAL GROUND
N.T.S.

FIGURE 4.10 (C)

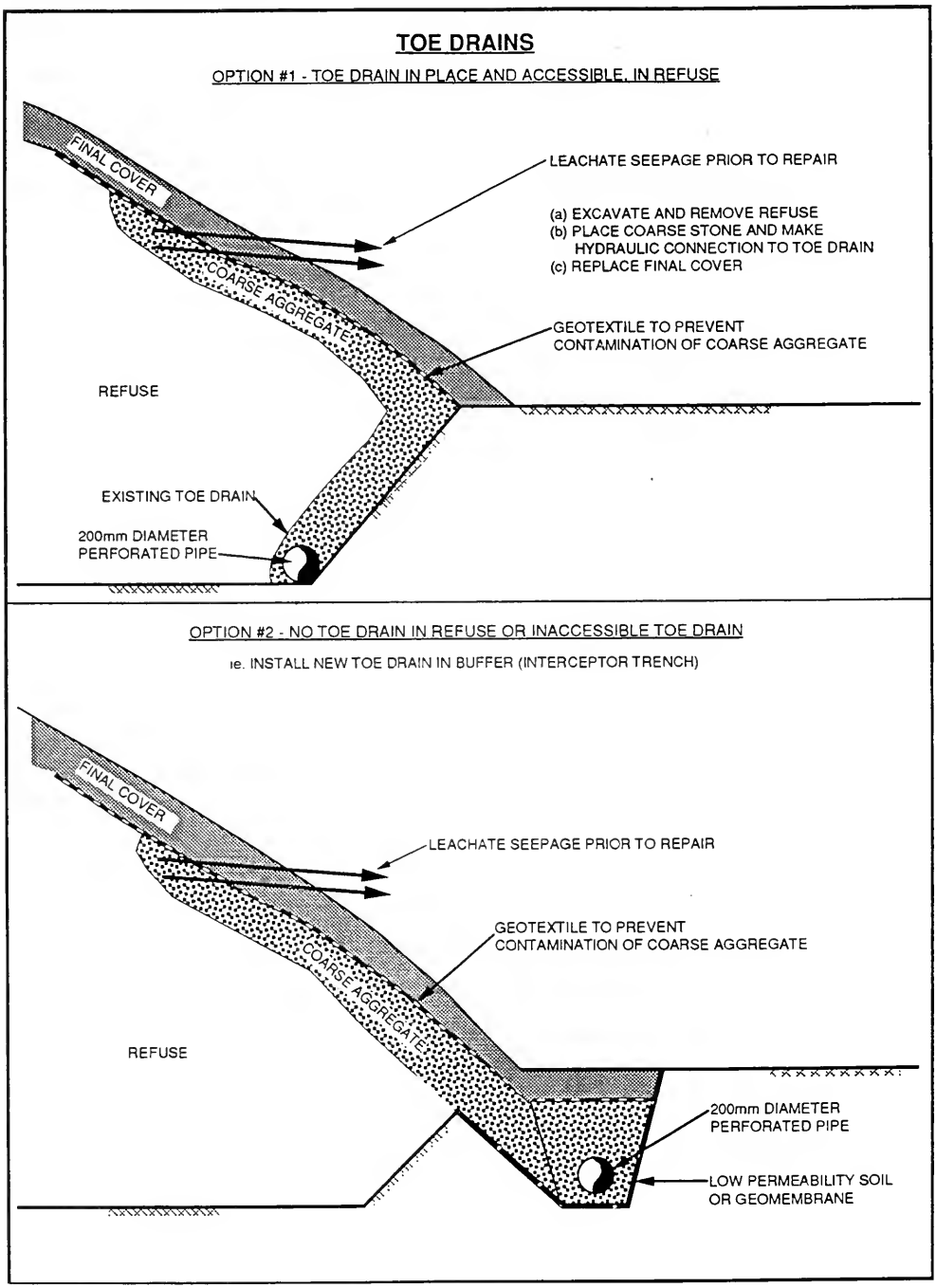

TOE DRAINS
OPTION #1 - TOE DRAIN IN PLACE AND ACCESSIBLE, IN REFUSE
FINAL COVER
LEACHATE SEEPAGE PRIOR TO REPAIR
(a) EXCAVATE AND REMOVE REFUSE
(b) PLACE COARSE STONE AND MAKE HYDRAULIC CONNECTION TO TOE DRAIN
(c) REPLACE FINAL COVER
COARSE AGGREGATE
GEOTEXTILE TO PREVENT CONTAMINATION OF COARSE AGGREGATE
REFUSE
EXISTING TOE DRAIN
200mm DIAMETER PERFORATED PIPE
OPTION #2 - NO TOE DRAIN IN REFUSE OR INACCESSIBLE TOE DRAIN
ie. INSTALL NEW TOE DRAIN IN BUFFER (INTERCEPTOR TRENCH)
FINAL COVER
LEACHATE SEEPAGE PRIOR TO REPAIR
GEOTEXTILE TO PREVENT CONTAMINATION OF COARSE AGGREGATE
COARSE AGGREGATE
REFUSE
200mm DIAMETER PERFORATED PIPE
LOW PERMEABILITY SOIL OR GEOMEMBRANE

FIGURE 4.10 (D)

TYPICAL PURGE WELL CROSS-SECTION

(No. And Spacing Of Purge Wells As Required By Site Conditions. Barrier Wall Optional, As Required For Containment.)

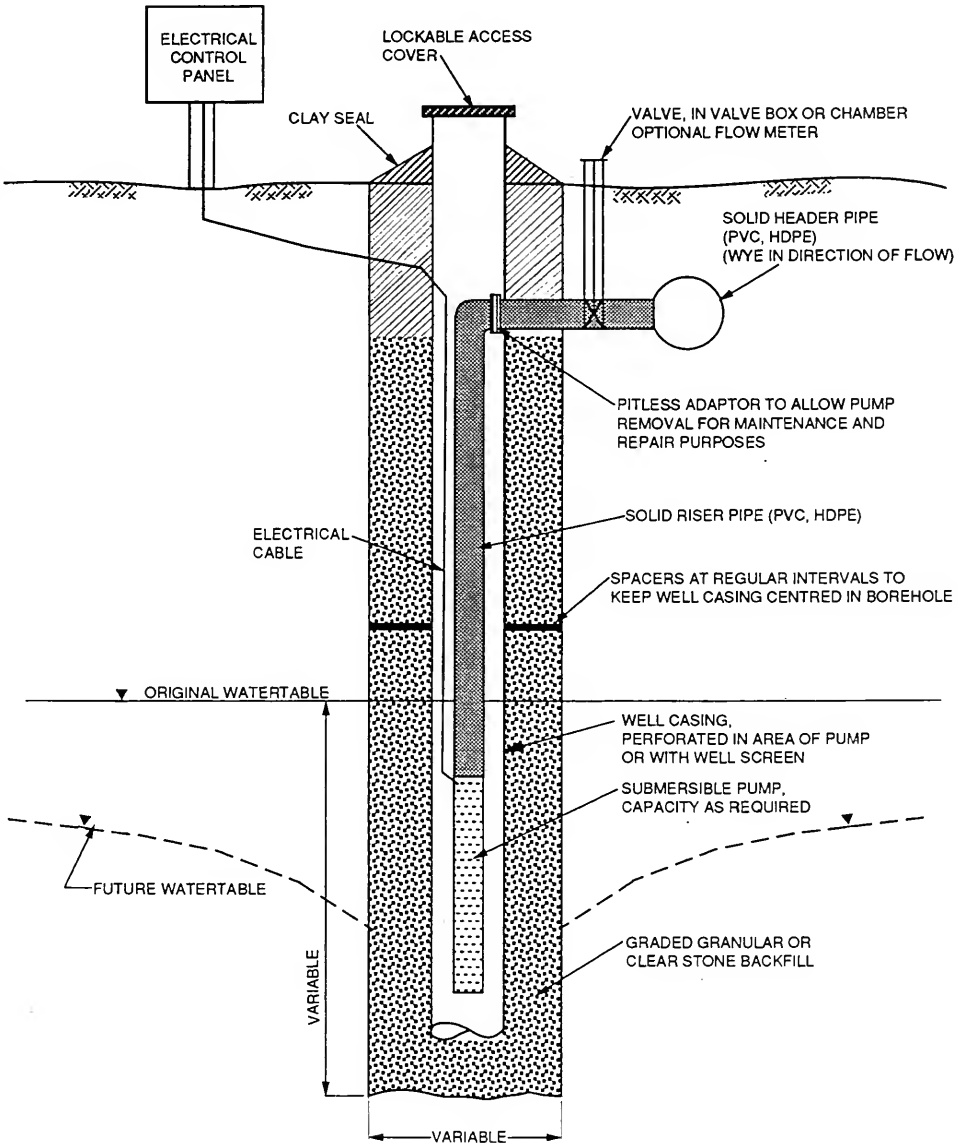


FIGURE 4.10 (E)

TYPICAL LEACHATE MAINTENANCE HOLE DETAIL

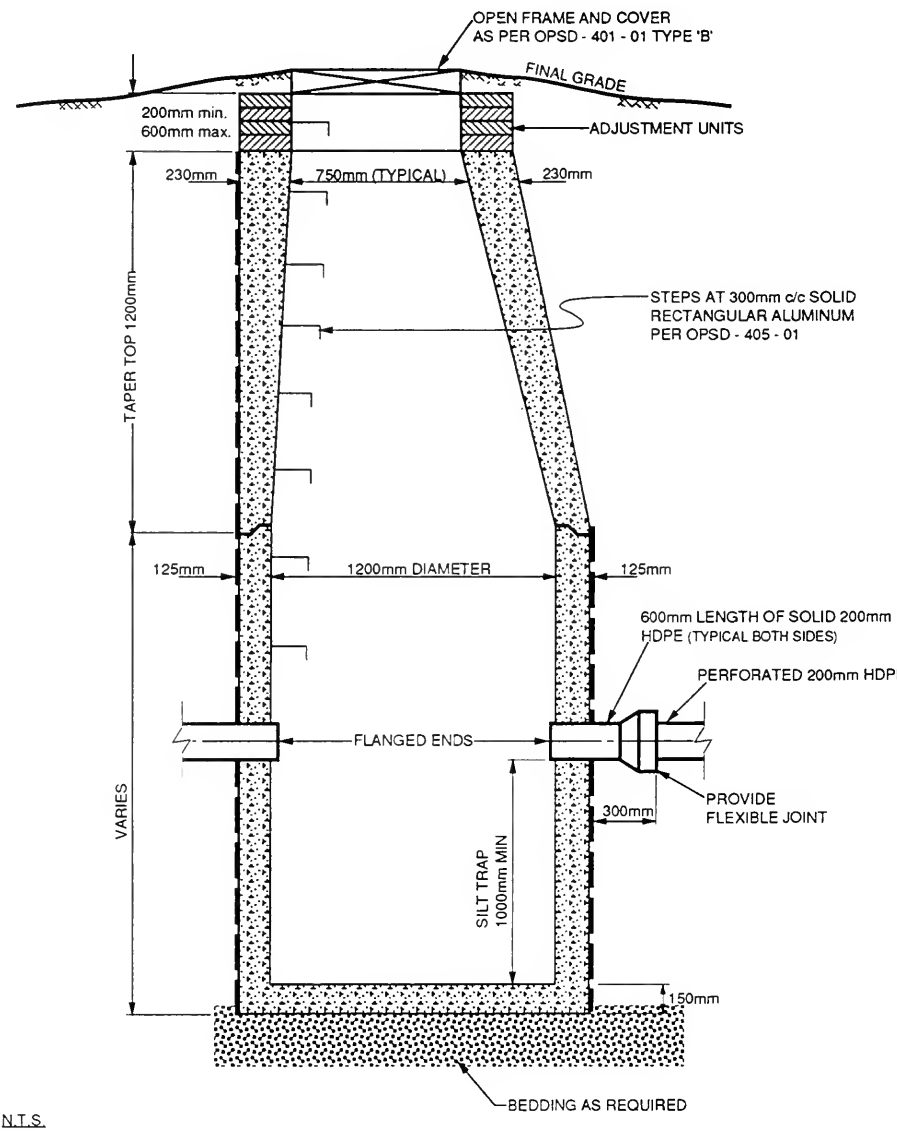
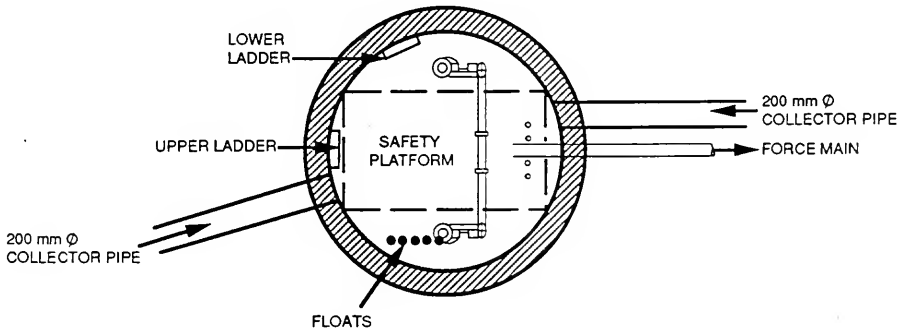
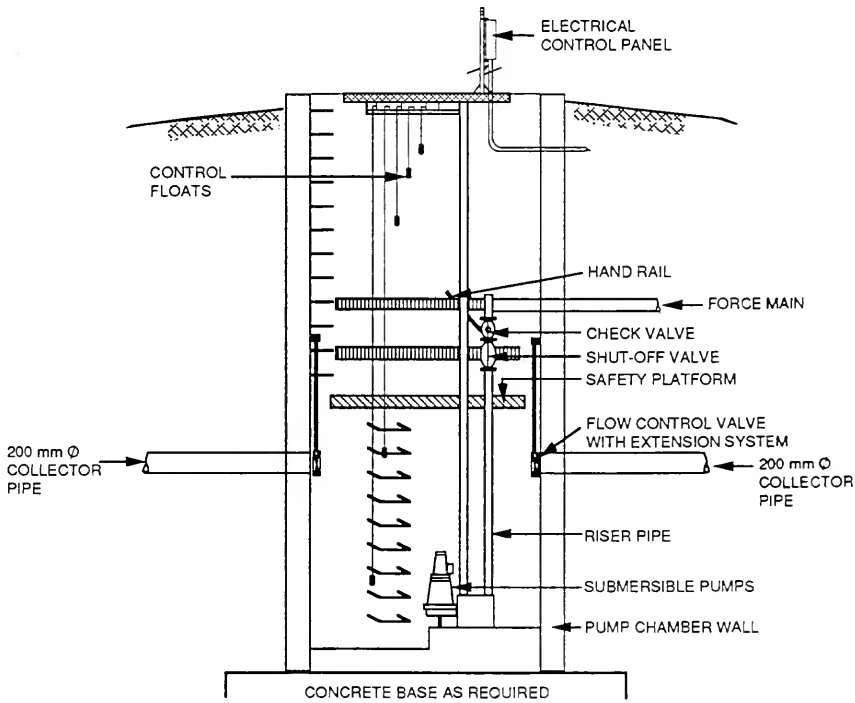


FIGURE 4.10 (F)

TYPICAL LEACHATE PUMPING STATION



PLAN VIEW



ELEVATION

FIGURE 4.10 (G)

4.11 GAS CONTROL

4.11.1 Rationale

The intent of gas control is to ensure the safe use of adjacent lands and protect structures from migrating gases generated from the decomposition of landfilled waste. It is therefore necessary to avoid non-predicted gas migration in the subsurface, in particular, movement toward enclosed spaces where it could potentially accumulate to flammable or explosive concentration.

4.11.2 General Requirements

The preferred method of dealing with landfill gas migration is to provide adequate buffer area that will allow for natural attenuation (natural venting) to the atmosphere. Landfill gas must be prevented from migrating, in the subsurface, beyond the outer boundaries of the buffer area or towards structures, where it may accumulate.

At most of the existing landfill sites in Ontario, the buffer area prevents significant off-site migration. Where the buffer area does not adequately protect the adjacent land uses, engineered gas control facilities are required. Requirements for dealing with the migration of the landfill gas, including the need for any engineered gas control system, should be determined on a site specific basis.

The engineered gas control facilities normally involve equipment that intercepts the landfill gas in the subsurface and discharges it to the atmosphere. The collected gas, alternatively, may be incinerated or recovered for energy use. Accordingly, there is a requirement for such systems to have an approval under Section 9 of the EPA.

a) Gas Generation and Hazards

i) Landfill gas is generated from the decomposition of the landfilled wastes and is mostly composed of methane, carbon dioxide and low or trace levels of organics and inorganics. The gas generation can continue at an appreciable rate for decades after the placement of the waste.

It must be assumed that the production of the landfill gas, in particular methane in potentially hazardous concentrations, will continue indefinitely unless demonstrated to be otherwise.

ii) The predominant concern with landfill gas is the potential fire and explosion hazards of methane gas. Additionally, the landfill gas can be an asphyxiant or a source of odour. Other landfill gas constituents, which are low or trace levels

of mostly organics, can be a health concern if allowed to accumulate to elevated levels.

b) Gas Migration

i) The methane generated in sanitary landfills can migrate through gas permeable soil for a significant distance. Migration of methane at concentrations of up to 10 percent of the lower explosive limit (LEL) has been found to extend up to 200 metres at some Ontario sites when the ground surface is frozen or very wet, conditions normally found during the winter in Ontario. Gas can also migrate along conduits formed as a result of construction of water and sewer mains, underground communication networks, etc., where loose or porous fill is used beneath or around pipes or protective housings.

ii) Generally, it is considered that methane gas migration, of any significance, may extend for a distance of ten (10) times the depth of the landfill between the ground surface and the water table.

iii) Because methane is lighter than air and because of the pressures induced by continuing gas generation, landfill gases tend to rise and, where vertically restricted, move laterally.

iv) Methane moves through the soil by convection where the pressure gradient is the driving force, or by molecular diffusion where the driving force is the concentration gradient. The flux, by way of diffusion, is relatively slight as compared to convection. In coarse-grained soil, convective movement may be rapid even where the pressure gradient is slight. The movement of gas through fine-grained, dry soils is anticipated to be mostly by diffusion. There is not likely to be significant gas flux through wet, fine-grained soils (silt and clay).

v) To avoid uncontrolled gas migration, escape routes for gases are often constructed as the landfilling proceeds, particularly at large disposal sites.

c) Buffer Area and Natural Barriers to Gas Migration

In the buffer area, natural barriers to landfill gas will exist under the following circumstances:

- The ground is saturated (100% of the pores filled with water) from the surface to an elevation less than the landfill base. The presence of permanent stream, lake or swamp is generally, but not always, evidence of such conditions.

- There is an intervening ravine, valley or excavation with a base at an elevation lower than that of the landfill base that will force any methane to vent to the atmosphere.

In the event that natural attenuation of gas is the chosen control method, the landfill design shall be such as to predict the movement of landfill gas, to monitor the actual situation, to confirm or refute the prediction and to construct gas control facilities if monitoring indicates that they are necessary. Gas Control facilities include the barrier system, pressure ventilation system, active ventilation system, and combinations.

c) Investigation of Gas Migration at Typical Landfill Sites

i) Migrating methane can pose a hazard to people and structures, including sewers, constructed close to landfills. This potential hazard may affect proposed development land not necessarily owned or controlled by the owner of the landfill. The greatest risk is to buildings and structures located either directly over or very close to the contact zone between undisturbed, slowly permeable ground adjacent to the fill and the landfill itself. Settlement of the landfill, which always occurs, can cause a crack to open which forms a large conduit for landfill gas to follow. It is necessary to verify that buildings erected close to landfills will be safe when constructed and in the future. The installation, where necessary, of building monitoring devices and alarms can assist in the protection of on-site structures.

ii) Investigations required to evaluate the potential methane hazard at active landfills are the responsibility of the site owner and operator. The investigation should be carried out by a competent professional experienced in the field of gas migration.

iii) The purpose of the investigation include the following:

- to determine if a natural barrier exists;
- to determine that the fill does not contain methane concentrations in excess of 10 percent of the lower explosive limit (LEL);
- to determine that adjacent buildings and structures will not be at risk from methane;
- to define the extent of the lateral migration of methane; and
- to assist in determining the need for and design of gas control systems.

iv) Generally, the investigator will install boreholes to verify subsurface stratigraphy, locate the water table, determine the range of seasonal fluctuations of the water table, identify the composition of the waste and determine the

extent of the fill. Based upon these site conditions, a system of probes to measure gas concentrations can be designed.

The design of an exploratory investigation will vary depending upon the geologic setting, and the characteristics of the landfill. The investigation should consider subsurface conditions above the water table that might affect the migration of gas. Monitoring of the gas probe system should extend over a long enough period to relate observed gas conditions to changes that may be seasonal.

A gas probe is illustrated in Figure 4.11 (A). Probes installed in or overlying the landfilled waste may require additional considerations for possible damage due to waste settlement.

v) It is becoming more and more evident that the hazard of landfill gas is related more to flux of gas than to concentration of the gas in the soil atmosphere at the building site. Because of the normal sluggish rate of air exchange between the soil and the atmosphere at depths greater than one to two metres, methane produced, or moved into an area, below that depth is likely to persist at high concentration. There appears to be little correlation between the concentration of methane at depth and the rate of flux. Unfortunately, the state-of-the-art for measuring gas flux from the soil outside a building into small closed portions of the building has not reached the stage where it can be accurately measured in place of concentration as a measure of the hazard. Where the measurement of the flux is not available, the methane concentration could be an indicator of the methane hazard. The ventilation capacity of a building can be checked during the evaluation of potential gas problems. Therefore, an adequate buffer distance needs to be established, or engineered gas control facilities must be installed to protect properties near active and closed landfills.

d) Odour Control

i) The landfill gas is a source of odour. It's natural dissipation or discharge to the atmosphere should not result in unacceptable off-site odour impacts.

ii) Where necessary, gas incinerators (upon collection) can provide control of landfill gas and malodour. Experience with alternative measures for odour control has shown that soil cover, incineration or utilization as energy can be relied upon for effectiveness.

4.11.3 Gas Interception Systems

The presence of methane in the ground around landfills, and its pattern of migration under the worst case conditions must be understood at the design stage of the landfill. Control measures and remedial actions are to be undertaken, where necessary, during operation or following closure.

Construction at landfill sites requires special foundation treatment to deal with excessive settlement and the installation of gas control systems. These add significantly to the cost of such construction. Further, there is risk that gas control systems that may be adequate when a building is finished, may not be adequately maintained, particularly where ownership is likely to change. It is generally held that closed landfills are not a suitable locale for construction of residential dwellings.

Landfill gas interception facilities include the barrier system, pressure ventilation system, active ventilation system and combinations.

a) Barrier System

This system essentially comprises a low-permeability barrier, as illustrated in Figure 4.11 (B), which may be constructed of earth, plastic or rubber materials, to impede the convective and diffusive flow of methane. Barrier systems are not impermeable, and can permit the passage of small quantities of methane under normal conditions. Consequently, some active or passive ventilation may be required to dissipate any gas moving through the barrier.

Generally, a soil barrier is resistant to chemical and bacterial deterioration, but may be susceptible to the development of cracks if the soil is dried out, providing preferential channels for gas migration. Soil barriers have not been utilized commonly for landfill gas containment; being costly below a depth of 10 metres and without assurance of uniform compaction densities required for effective operation.

Various plastics have been used for barrier material including polyethylene (PE), polyvinyl chloride (PVC), butyl rubber, hypalon, and chlorinated polyethylene (CPE). These materials are manufactured with high resistance to chemical and bacterial deterioration, and low gas permeability specifications.

As with the soil barrier, the major constraints to the utilization of membrane barriers are the high costs of excavation below a depth of about 10 metres and the sustained integrity of the liner materials. Thus, this system is normally suitable for a physical setting where the landfill has shallow depth or where the water table is high. Extension of the system to the water table or a low-permeability zone is essential to ensure effective control of landfill gas.

b) Passive Ventilation System

A passive ventilation system is designed to provide greater permeability and diffusivity potential than the adjacent native materials, and thereby induce the migrating landfill gas to move towards the atmosphere rather than continue through the subsurface, as shown on Figure 4.11 (C). Generally, the system is considered more effective in controlling convective flow than diffusion flow.

Typically, a passive system consists of a trench of highly permeable material, which under favourable atmospheric and subsurface conditions, may be effective in preventing lateral gas movement. If however, the subsurface permeability of the native material is similar to or higher than the trench material, or if the trench surface becomes sealed by freezing or bacterial action reducing ventilation capacity, gas may move past the system. Consequently, adequate ventilation is required on the down-gradient side to ensure proper interception of methane.

As with the barrier system, the passive ventilation system may have to extend through most of the zone through which methane could migrate, and its utilization is largely controlled by the practicable excavation depth.

It is common practice to install lateral perforated collector pipes in a granular trench, connected to riser pipes, which may also be equipped with rotary or fixed vane gas exhausters, to maximize the passive-system efficiency. These exhausters are capable of moving substantial quantities of gas under normal climatic conditions. For example, a 200 millimetre fixed vane exhauster is capable of exhausting about 2 cubic metres per minute at a temperature differential of 5°C between source and atmosphere, and a wind velocity of 6 kilometres per hour.

Fixed exhaust vanes should last for many years, and require little or no maintenance. Rotating vanes may be more effective, but are prone to seizing from rust and freezing.

Individual vertical vent pipes, with and without exhausters, have also been utilized in an effort to control landfill gas movement. These pipes, which largely operate on the differential convective pressures, have a limited capture radius of a few metres dependent on the soil permeability. Gases collected by this type of system are generally allowed to vent directly to the surface, if not generated at rates sufficient to cause odour problems.

c) Active Ventilation System

Active or forced ventilation systems operate on the principle that a zone of negative pressure along a landfill boundary will prevent movement of landfill gas across that boundary.

A typical active system consists of several wells, similar to those shown on Figure 4.11 (D), attached to a common header and connected to a gas exhaust pump, as shown in Figure 4.11 (E), which provides negative pressure, causing the movement of gases towards the well system.

A positive pressure system has been used at a few locations. This has a similar design, with the exception that the fan introduces atmospheric air to the subsurface, thereby creating a positive pressure curtain (in contrast to a negative one) to prevent lateral gas movement. The system may require less energy than an exhaust system, but may also increase the fire hazard and gas-migration potential within the landfill itself.

There are two classes of active-exhaust systems, high-flow and low-flow. A high-flow system causes the movement of large gas volumes, with a substantial influx of atmospheric air through the landfill cover. Although highly effective, the operating costs may be higher and the explosion and fire hazards within the landfill may be increased by the introduction of oxygen. Continued replenishment of oxygen within the landfill may also promote aerobic rather than anaerobic decomposition of waste. Combustion of the exhaust gases, if required, may be inhibited by excessive air dilution.

A low-flow system provides the minimum head differential required to maintain the negative pressure barrier. Consequently, intrusion of atmospheric air into the landfill is usually lower.

Although gas-capture is more assured for a high-flow system, the low-flow system is generally considered more appropriate as an active-ventilation system having lower energy expenditure, lower fire and explosion hazard, and maximizing methane concentration for subsequent recovery or burning.

d) Design

Since the life of a site being provided with a gas system may extend to 10 or 20 years, it may be necessary to phase-in the construction of various elements. Both the horizontal and vertical components of collector pipes or wells can be capped and extended at a future date when more waste is in place. Increased or new fan capacity and needed piping changes or additions can be made as more gas interception components are brought into operation.

The design principles of an interception systems are the same regardless of the size and capacity of landfill sites.

Passive Barriers

The location of the upper and lower extremities of the passive barrier would be set by end-use constraints and a practical distance from the waste material, respectively. The horizontal distance between the top and toe of the barrier is dependant on the safe slope that can be excavated to ensure stability in the soil beyond the waste. The barrier is to be laid in sections to allow handling and is to be effectively sealed in the field at seams.

Passive Ventilation Systems

The components of passive ventilation systems are to be designed to provide for satisfactory collection and discharge of gas that collects in a trench filled with granular material of greater permeability than the adjacent native soils.

Active Ventilation Systems

In essence, the design considerations include:

- the selection of a horizontal alignment for the system;
- the definition of the nature of the material along that line between the surface (ultimate) and the lowest elevation of the water table;
- the testing of a gas extraction well in the material(s) for its zone of influence at various gas withdrawal rates;
- the determination of whether gas extraction wells or a surface or trench collector system should be used;
- selection of fill material(s) appropriate for the natural soil and required system permeability; and
- the siting of a fan house at a suitable location.

The fan house and mechanical equipment are to be designed to extract and exhaust the gas using spark-proof and explosion-proof features, condensate drainage, vibration isolation to minimize noise, and a soil gas pressure switch, both to monitor system operation and to signal breakdown at remote locations in the event of system failure.

Common design configurations of trench vents are illustrated in Figure 4.11 (F).

4.11.4 Gas Interception - Safety

During the drilling of gas wells into the waste fill area, there is the basic need to prevent personnel from either being overcome by malodorous conditions at the well head or slipping into the open, large auger holes that may be over 10 metres deep.

As methane is a flammable gas, particular attention to potential ignition sources should be made. No smoking or any open flame is to be permitted near gas interception system that is being or has been constructed, regardless of whether or not it is operating.

The site operator should provide a health and safety plan for both construction and operations of the interception system. Subcontractors involved in construction or

maintenance may choose to use the site owner's health and safety plan as a guide in developing their own plan.

The health and safety plan is to provide a site description including hazard evaluation, measures for confined space entry and protection of employees in excavations, as well as emergency information, a work plan with monitoring and respiratory protection, and recommendations for discontinuation procedures.

4.11.5 Management Upon Gas Interception

a) Emissions Standards

Each gas interceptor system (i.e., emission) shall operate within the framework of the Regulation 308 and its point of impingement concentrations. The acceptable levels of emission would be detailed in the application for and the Certificate of Approval as required under Section 9 of the EPA.

b) Contingency Incineration

It may be necessary to retrofit an incinerator to the existing gas interceptor system as a contingency solution to an odour emission problem. This requires approval under Section 9 of the EPA. In certain exceptional situations, the results of monitoring the landfill gas may necessitate the interception and control of undesirable air contaminants.

The retrofit for an incinerator involves construction of a burner(s) and pad, complete with fan discharge piping and controls for combustion air and gas pressure. The burner and new piping places additional friction in the system to the flow of gas, which must be overcome by increased performance of the fan.

Following installation for contingency incineration, an emission testing program is required to confirm that the emission standards, as set, have been achieved by the facility.

c) Methane Recovery and Utilization

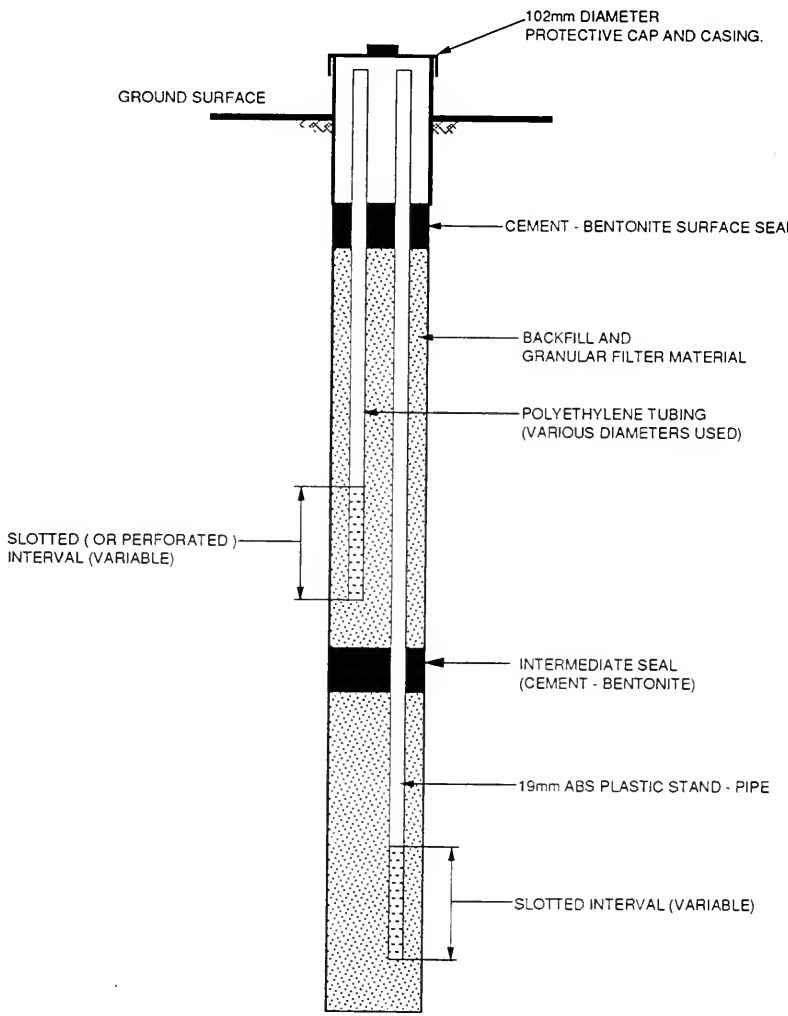
The landfill gas is a potentially recoverable source of energy. Landfill gas, with methane concentration of 50%, has a heat value of about 505 BTU/cubic foot as compared to 1,030 BTU/cubic foot for natural gas.

It is advantageous to foresee during the design of a gas interception system, the adaptation for gas recovery and utilization. The gas interceptor system has an operational goal of achieving a wall of negative pressure in the subsurface to prevent movement of gas from the landfill. A good recovery system has an operational goal of drawing a methane-rich mixture from the

site, and this would be greatly hampered by efficient collection along the perimeter of a landfill. It is only by progressively adjusting the valves of the collectors and monitoring for off-site migration that a system can effectively achieve both goals.

d) Multiple Purpose (Interception, Recovery, and Odour Control)

The multiple demands can be required of a gas interception system at a landfill site are the that include simultaneous objectives to achieve interception, recovery and odour control. This can result from a system designed with anticipation of the three competing but not mutually exclusive goals. Such a system will require numerous redundant legs or wells, valves for each element and each branch, by-pass lines to incinerate when gas quality precludes recovery and a control system that recognizes a defined priority in the goals. Accordingly, the system must achieve its interception goal first (as a matter of public safety), its odour control objective secondly and the aim of recovery only when the higher order purposes have been met.



GAS PROBE CONSTRUCTION DETAILS

FIGURE 4.11 (A)

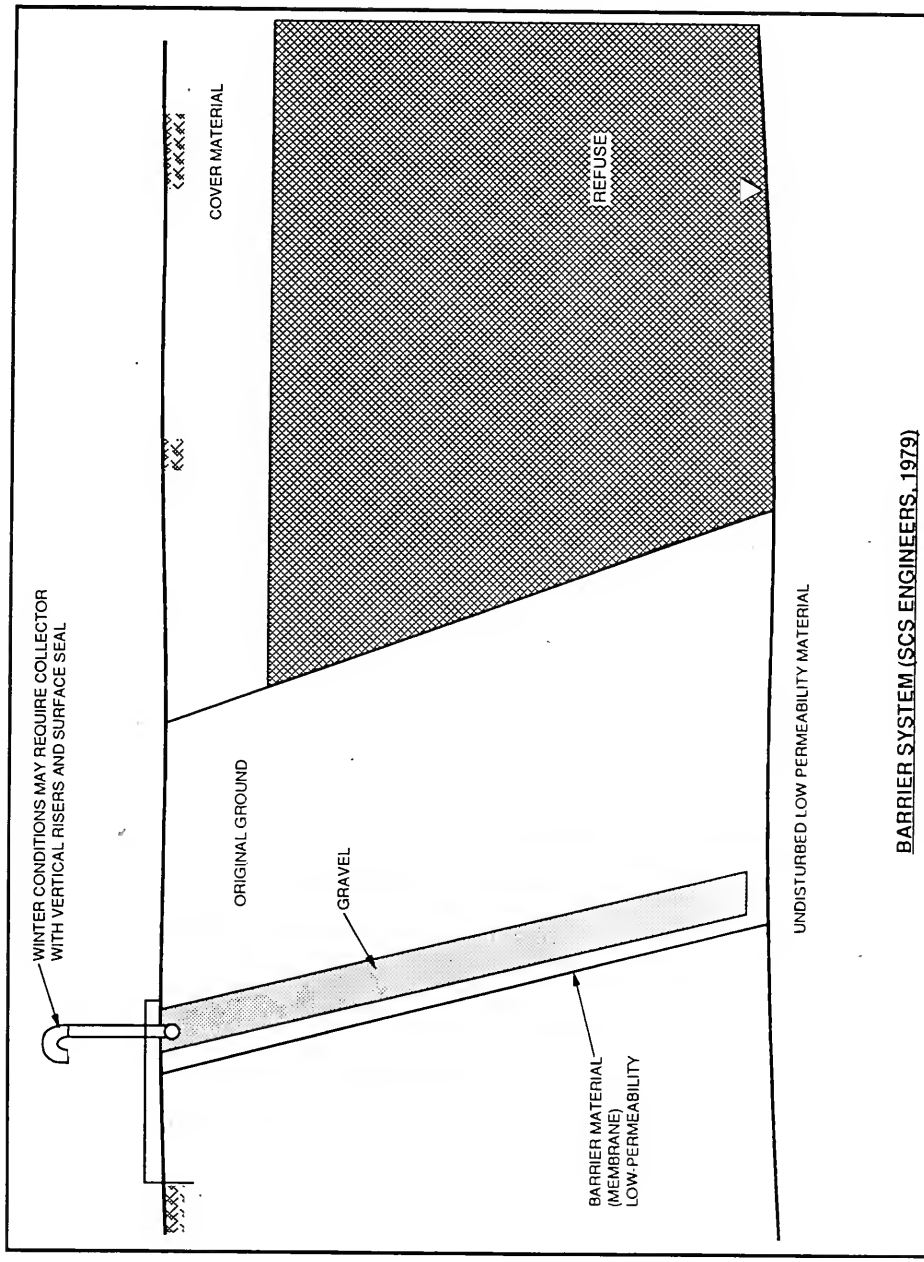
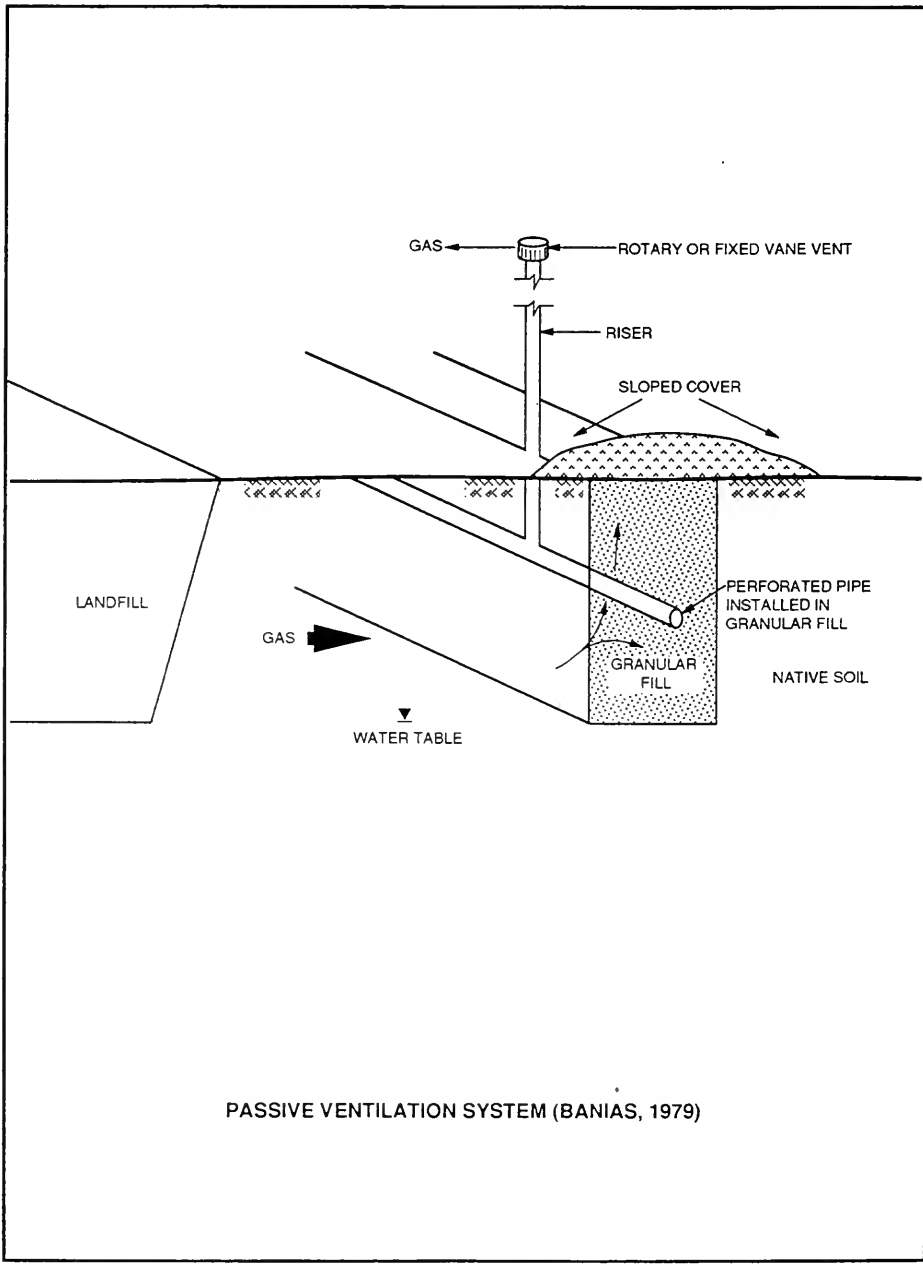

WINTER CONDITIONS MAY REQUIRE COLLECTOR WITH VERTICAL RISERS AND SURFACE SEAL
COVER MATERIAL
REFUSE
ORIGINAL GROUND
GRAVEL
BARRIER MATERIAL (MEMBRANE) LOW-PERMEABILITY
UNDISTURBED LOW PERMEABILITY MATERIAL
BARRIER SYSTEM (SCS ENGINEERS, 1979)

FIGURE 4.11 (B)



PASSIVE VENTILATION SYSTEM (BANIAS, 1979)

FIGURE 4.11 (C)

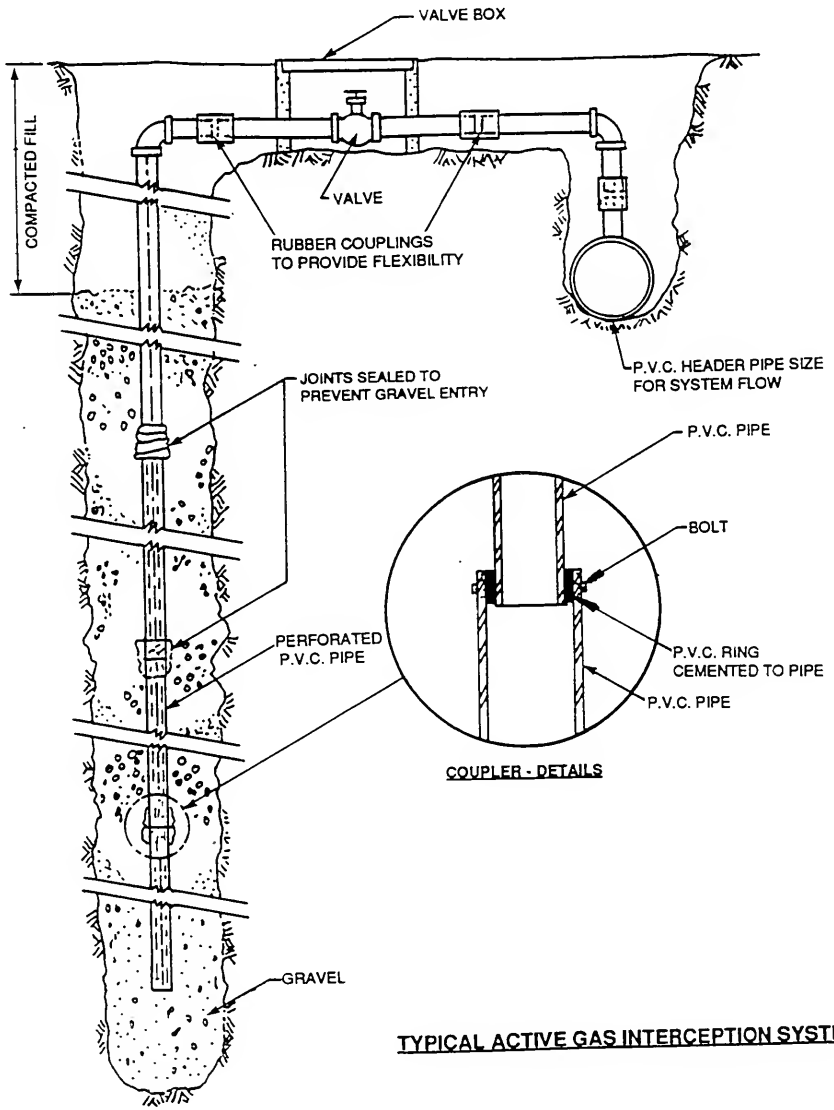
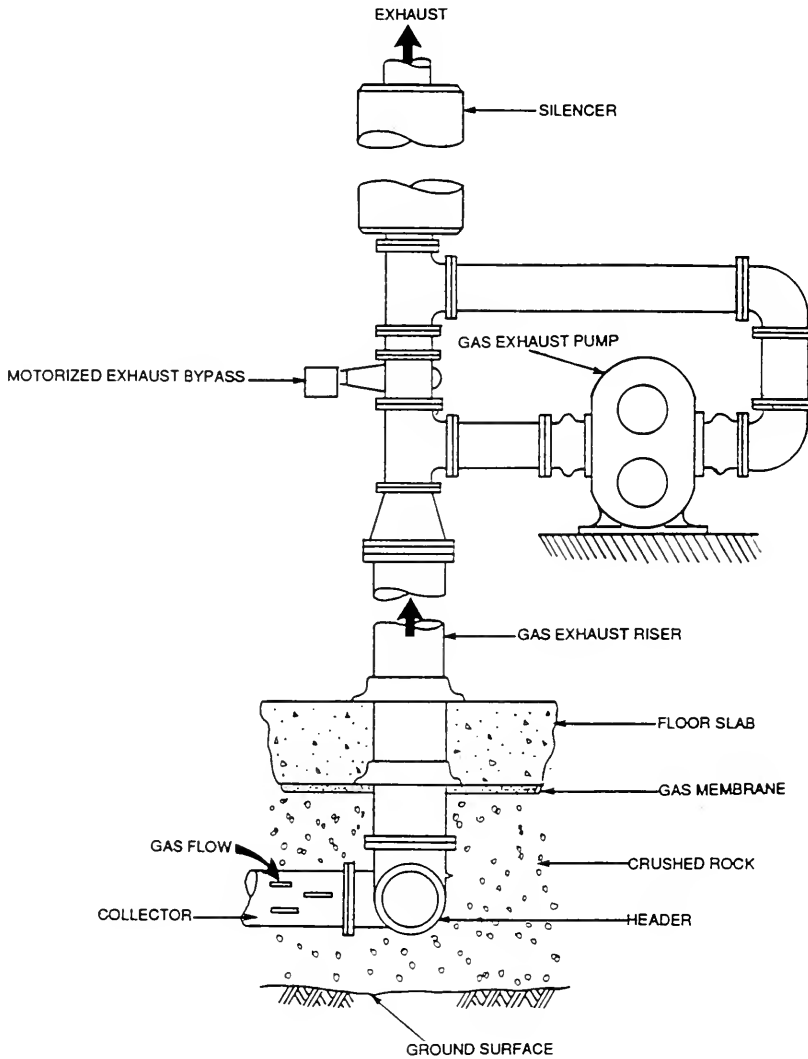

VALVE BOX
COMPACTED FILL
VALVE
RUBBER COUPLINGS
TO PROVIDE FLEXIBILITY
P.V.C. HEADER PIPE SIZE
FOR SYSTEM FLOW
JOINTS SEALED TO
PREVENT GRAVEL ENTRY
P.V.C. PIPE
BOLT
PERFORATED
P.V.C. PIPE
P.V.C. RING
CEMENTED TO PIPE
P.V.C. PIPE
COUPLER - DETAILS
GRAVEL
TYPICAL ACTIVE GAS INTERCEPTION SYSTEM

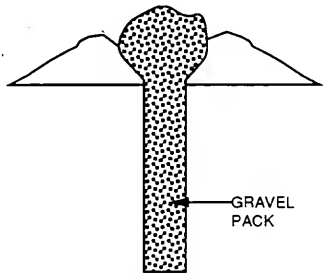
FIGURE 4.11 (D)



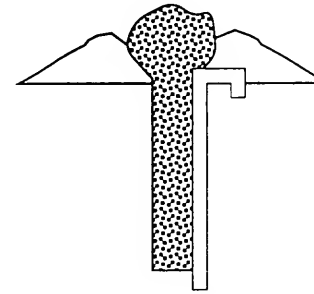
ACTIVE VENTILATION SYSTEM - EXHAUST FAN PARTICULARS
(ENGINEERING - SCIENCE, 1976)

FIGURE 4.11 (E)

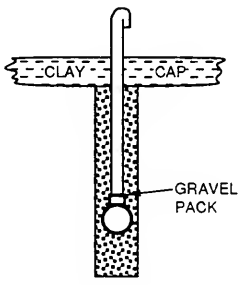
COMMON DESIGN CONFIGURATIONS OF TRENCH VENTS



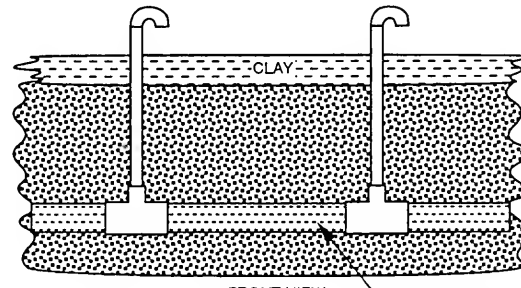
(a) Open Trench



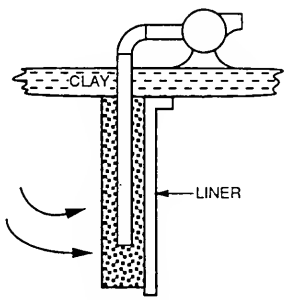
(b) Open Trench With Liner



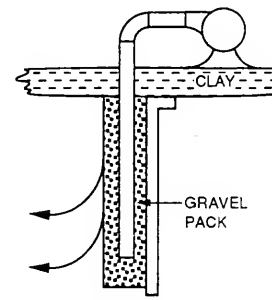
SIDE VIEW



(c) Closed Trench With Lateral And Risers



(d) Induced Draft



(e) Air Injection

FIGURE 4.11 (F)

4.12 CONTINGENCY PLANS

4.12.1 Rationale

A Contingency Plan is an outline of remedial actions to be undertaken in the event of unforeseen problems, failure of the landfill to perform as predicted, as well as any emergency situations. This ensures that a plan of remedial actions is prepared and available for implementation to ensure public health and safety and to maintain protection of the environment.

4.12.2 General Requirements

a) Under Regulation 347, Section 11, measures are required to be taken, if necessary, for collection and treatment of contaminants and prevention of water pollution. In anticipation of extreme weather conditions that may prevent the use of the landfill site, provisions shall be made for the use of alternate waste disposal site.

b) The Contingency Plan should identify and outline back-up measures that are in addition to the already approved design features and management activities for the landfill. The financial considerations associated with such measures should also be identified. The "trigger" for implementation of remedial actions of the Contingency Plan should be clearly described as the recognition of an emergency is a necessary precursor to a remedial response.

The Contingency Plans should deal with incidents such as non-predicted paths of leachate or gas migration, liner failure, leachate collection or gas control system failure, surface water contamination, equipment failure, or dealing with inappropriate wastes disposed of in the landfill. Also, conceptual measures, including provisions for use of alternative waste disposal site, in response to labour disputes, temporary site closure, premature permanent closure due to operational problems, etc. can be included in the Contingency Plan.

The Contingency Plan should be reviewed for adequacy on a regular basis. An appropriate time may be during the time of the preparation of the annual or status report for the landfill. The analysis of the monitoring data may indicate the need to implement the Contingency Plan, and to fully detail an aspect of the Contingency Plan for implementation. Also, the availability of new technologies over time may influence the Contingency Plan.

4.12.3 Ground Water and Surface Water Contamination and Gas Migration

Contingency Plans are site-specific and should address the potential scenarios for failure and the remedial measures recommended.

Identification of a problem is the responsibility of the landfill owner and operator. As such, a sound monitoring program and analysis of the monitoring data is an important aspect of the landfill operator's Contingency Plan. Further, the implementation of the Contingency Plan is the responsibility of the landfill owner and operator. The installation of remedial works requires an application for amendment to the site's Certificate of Approval under Part V of the EPA and/or under Section 53 of the OWRA.

a) Ground water contamination, surface water contamination, and/or gas migration may become evident over a relatively long period of time through the on-going analysis of monitoring results.

   Ground water contamination could result due to liner or leachate collection system failure. By the time failures are evident, it is usually extremely difficult or prohibitively costly to excavate into the landfill to expose the liner or underdrain system and locate the damaged parts for repair or replacement. Corrective methods can include the installation of leachate control systems (discussed in Subsection 4.10) such as purge wells in the fill or in the buffer; barrier system such as a sheet pile wall, grout curtain, or slurry trench; or toe drain or perimeter collection system. Where agreements can be reached and with the appropriate municipal and provincial approvals, the adjacent properties can be purchased or established as Contaminant Attenuation Zone.

b) Surface water contamination may result when leachate breakout occurs through final cover as a result of inadequate hydraulic connection between successive landfill lifts. Leachate seeping from the fill will then be collected by ditches or swales which eventually drain off-site. To rectify this problem, the area of the seep is excavated and the waste disposed of in an appropriate manner. The excavation is then filled with clear stone and hydraulically connected to lower lifts of refuse, the leachate underdrain system or a toe drain at the perimeter of the site. If existing collection systems are not in place, it may be necessary to construct a toe drain if breakout conditions are severe. Figure 4.10 (D) provides illustrations of such measures.

c) Gas migration may also occur with time, and could result in an explosion hazard within on-site and off-site structures. Monitoring for gas migration and gas control facilities are generally necessary for larger landfill sites. Details of typical gas control systems are described in Subsection 4.11.

4.12.4 Financial Assurances to Implement Contingency Plans

The implementation of contingency plans will generally require significant financial input. Landfill owners and/or operators are normally required to provide assurance that funds will be available to implement corrective works. For the privately owned landfills, financial assurances can include surety bonds, insurance policies, waste management funds that are accumulated based on tipping fees and so on. The amount of financial assurance is site-specific and will require periodic review. The users of the Guidance Manual are referred to the MOEE Financial Assurance Guideline. If monitoring results indicate that site integrity and safety are no longer a concern, then the dedicated funds may be re-allocated for a different purpose.

4.13 FINANCIAL RESPONSIBILITY REQUIREMENTS AND GUARANTEES

4.13.1 Rationale

All owners and operators of landfill sites have a responsibility to ensure that they have adequate funds for remedial or contingency work during site operation and all aspects of closure and post-closure care. This includes allowances for maintenance, monitoring and remedial work that may be required to respond to both sudden and non-sudden occurrences on and off-site.

4.13.2 General Requirements

a) All site owners/operators should have adequate funds for any remedial work for non-anticipated occurrences on-site (such as, waste re-location, on-site road repair and leachate collection to prevent off-site contamination) and off-site remedial work (such as, leachate and gas control systems), as well as, for anticipated gas and leachate control systems. These funds would also be used for routine activities such as monitoring and closure requirements.

b) Financial guarantees are normally required for private site owners/operators. Similar forms of financial assurance may be required for municipally owned sites at the MOEE Director's discretion.

c) The amount of the financial guarantee is site-specific. The assessment of the need and amount should cover a period of at least 25 years following site closure. The adequacy of the financial assurance should be reviewed as part of site status reporting. If site monitoring data indicates the landfill no longer possess any concern to the environment, the funds may no longer be needed.

4.13.3 Procedures

The MOEE sets out site-specific requirements for financial guarantees in each Certificate of Approval. Such guarantees have been provided either by way of surety bonds or letters of credit posted with the MOEE or by arrangements for government or municipal grants, through various waste management funding assistance programs.

Notwithstanding that government assistance may be available, it is the responsibility of all owners and operators of landfills to arrange all appropriate financing prior to application for the Certificate of Approval.

Owners/site operators of landfills are encouraged to establish sinking funds to meet closure and post closure costs. The funds can be built up using a portion of the tipping fees to provide the required financial resources by the planned closure date.

4.14 SITE PREPARATION REPORT

4.14.1 Rationale

The intent of the Site Preparation Report is to provide confirmation, by the landfill proponent, that the site has been prepared in accordance with the approved Design and Operations Plan as per the Certificate of Approval, prior to any deposition of waste.

Additionally, the Site Preparation Report serves as documentation of site-specific conditions, encountered during site excavation and development, that warrants modification to the original Design and Operations Plan. Where amendments to the Certificate of Approval are needed, the Report provides the necessary information to support such a request.

4.14.2 General Requirements

A Site Preparation Report should be submitted for all landfill sites. Possible exceptions may be very small sites at the discretion of the MOEE Regional Director.

Generally, the level of detail to be included in the Site Preparation Report should be consistent with the level of services, facilities and controls needed to operate the site.

In the case of larger, more complex landfill sites, the Site Preparation Report may be prepared and submitted in stages as landfilling operations proceed. The need for staging reports will be at the discretion of the MOEE.

The Site Preparation Report should include descriptions of the construction of waste disposal cells, liners, leachate control and collection systems, on-site roads plus other appropriate services and facilities. Additionally, the Site Preparation Report can include details of modifications to the original Site Design and Operations Plan that are necessary to accommodate site-specific conditions encountered during the excavation and development of the site. Such discrepancies should be described in the Site Preparation Report, as well as measures to accommodate and account for the differing conditions. Where modifications to the original Design and Operations Plan are necessary, such changes require approval through amendments to the Certificate of Approval. In such an event, the landfill proponent should provide sufficient details to enable the MOEE to review and approve any necessary modifications to the original Design and Operations Plan before any waste is deposited.

The Site Preparation Report is prepared and submitted by the landfill owner or operator to the respective MOEE Regional office. Frequently, the consulting professionals assist in the preparation of the Report.

4.14.3 Base and Final Contours

The preliminary design of the base and final contours of a landfill presented in the original Design and Operations Plan are normally based on physical constraints such as topography and hydrogeology, visual and noise impacts and a minimum site volume that is necessary to accommodate the quantity of waste to be disposed of during an established time period, usually 20 years or more. Optimization of the base and final contours is a normal undertaking for all landfill sites as site-specific details, such as geotechnical and hydrogeological constraints, are assessed and taken into consideration. The Site Preparation Report presents the revised contour plans where applicable.

4.14.4 Leachate Collection and Containment

Leachate collection and containment needs are site-specific, depending on the size, location and physical characteristics of the waste disposal site and adjacent land areas. For example, a particular site may require a liner and leachate collection system to ensure protection of the ground water resources. Details of the liner and leachate collection system, design and construction, may be modified from the original development plan or conceptual stage to the detailed design state and must be included in the Site Preparation Report.

4.14.5 Site Facilities and Services

Details of the construction of all site facilities and services such as roads, administrative and maintenance buildings, scales and scale houses, fencing, visual screening, berms, pumping stations, sewers, water supply systems, household hazardous waste storage areas, recycling bins, and various waste reduction or recovery systems should be provided.

The Site Preparation Report should include confirmation that the construction of all facilities and services has met all safety requirements of the provincial, municipal and federal regulations and that ample consideration has been given to mitigating the nuisance impacts from odour, noise, dust, litter and visual effects. Particular emphasis should be placed on mitigating potential hazards.

4.15 LANDFILL DEVELOPMENT AND WASTE DISPOSAL OPERATIONS

4.15.1 Rationale

The rationale for encouraging sound landfill construction and waste disposal operations is to ensure that operating procedures make effective use of available landfill space and that equipment and control works are operated and maintained properly to protect the environment and ensure safety on and off-site.

4.15.2 General Requirements

a) Regulation 347, Section 11 specifies that wastes shall be deposited in an orderly manner, compacted adequately and covered with cover material through proper landfilling operation.

b) Waste must be adequately contained in the space bounded by the base, the side slopes and the cover material. The process by which waste is deposited, spread, compacted and covered must be in accordance with the Certificate of Approval as detailed in its supporting document, the Site Design and Operations Plan. The waste disposal operations should proceed in coordination with the operations of other control systems (e.g., leachate, landfill gas, and surface drainage) which have been established or are planned at the landfill site. Waste disposal operations during winter conditions require special considerations and provisions.

   A landfill site is considered to have reached full capacity once deposited wastes (and cover material) has reached final approved contours. Addition of waste beyond the approved contours, regardless of any potential to settle down to approved contours, is not permitted unless it is specifically approved with an amendment to the Certificate of Approval.

4.15.3 New Landfill Sites

All construction work associated with the establishment of landfill sites should be carried out in accordance with the approved site design and the Certificate of Approval.

Owners and operators are advised that all critical construction activities should be carried out under the direct supervision of a registered Professional Engineer. The MOEE normally requires written confirmation from the engineer that the facilities have been constructed in

accordance with the approved plans and the Certificate of Approval. The critical construction activities include, where applicable, the following:

i) landfill base preparation;
ii) leachate collection system construction;
iii) leachate storage and transfer device construction;
iv) liner placement;
v) gas collection and control systems installation; and
vi) surface water impoundment construction.

4.15.4 Methods of Waste Disposal and Operations

All landfill operations with respect to excavation, waste placement, cell development, daily and intermediate cover placement, leachate handling and gas control are required to be carried out in compliance with the Certificate of Approval issued for the landfill site. Leachate handling and gas control systems, and their operational and maintenance requirements are discussed in Subsections 4.10 and 4.11. The two basic methods of developing/operating the landfill site, the trench method and the area method, are described in this subsection.

Waste should be unloaded at the working face, spread and compacted in the thicknesses and layers envisaged in the Site Design and Operations Plan. Use of landfill compactor or other heavy vehicles over the waste can optimize the use of the landfill volume. Cover material should be applied over the waste, typically on a daily basis.

To protect the operator and his equipment, the slopes should not be unduly steep. The slope of the disposal face should be no steeper than 3:1 (horizontal to vertical). Under winter conditions, flatter slopes of 4:1 or less may be necessary. On the other hand, to ensure that cover materials are conserved, level cover areas should be avoided.

The working face should be long enough for compaction equipment, haulage vehicles and snowploughs to function and manoeuvre without interference or obstruction.

a) Trench Method

The trench method is normally employed at smaller landfill sites. This method is better suited for flat or gently sloping land where the water table is deep below the surface. In rolling terrain, the trench can be self-draining. The selected location of the landfill site should have soil that is easy to excavate and is suitable to use as cover material. Excess excavated soil could be used for screening berms. A major advantage of the trench method is usually the immediate availability of soil for use as cover material without requiring expensive specialized equipment to haul it long distances from off-site borrow locations.

Figure 4.15 (A) illustrates a trenching operation. The ends of a trench are usually left open to provide entry for compaction equipment. Typically, at smaller landfill sites, a trench of sufficient capacity for about 6 to 12 months of operation is excavated. Depending upon the availability of excavating equipment, a second trench may be excavated in segments parallel to the first and the excavated material used to cover the first trench. There should be a minimum separation of one metre between the trenches for safety. This method of trenching also requires handling of cover material only once, which is a cost effective means of operation.

Waste can be compacted in horizontal layers approximately 2 metres thick, but sloping layers to form a ramp at one end of the trench are preferable to facilitate drainage. Successive layers can be compacted prior to placement of cell cover, to increase the waste to cover ratio.

Movable barriers can channel vehicles to the current disposal location. Several vehicles should be able to deposit wastes simultaneously. When trucks and private cars are to unload wastes simultaneously, access to both sides of the trench may be desirable. Wheel stops should be provided for safety purposes. Signs, indicating accident-avoidance procedures, should be posted. Working areas should not exceed 30 metres in width.

Small trenches are usually about 2 to 3 metres deep and are about two to three times as wide as the machine used for excavating the trench. Large trenches could be 10 to 15 metres deep, 20 to 30 metres wide and up to 100 metres long. Such trenches would serve landfill sites receiving approximately 300 to 500 metric tonnes of waste per day.

Some safety aspects for trenches are discussed in the Ministry of Labour's Regulations for Construction Projects and should be reviewed.

Advantages of the trench method include the following:

- Since landfilling takes place below the ground level, the visual impacts of the landfilling operation may be reduced to surrounding areas. Also, upon closure, the landfill "mound" is less visible or non-existent;

- The excavated soil can be used as cover material immediately or stockpiled for later use;

- Major earth moving equipment is required only occasionally, hence the equipment can be leased rather than purchased. For municipalities, the equipment can be easily shared with other municipal departments.

- Opportunity to make more efficient use of the land exists by utilizing the area method of landfilling over filled waste trenches;

- Where wastes are placed directly in the trench, the amount of blowing paper may be reduced;
- Portable litter fences, if required, can be easily located in strategic locations;
- Greater safety due to less traffic congestion at the active face. For example, the hauling vehicles unloading at the side of the trench will not interfere with the bulldozers and compactor working in the trench.

Disadvantages of the trench method include the following:

- The method is unsuitable when the rock is close to the ground surface or, in certain cases, the water level is high;
- If heavy (cohesive) soils, such as clay are present, trench excavation would be restricted to the dryer, warmer months;
- Surface water may collect in the trench and cause operational problems;
- Under extreme winter conditions, trench disposal may become temporarily impractical; and
- The soil from the excavation of the trench, if in excess of the amount that can be immediately used as cover material may require stockpiling. This is "double handling" and is an extra expense.
- Where several trenches are established at the site, the land is inefficiently used. e.g., the land between the trenches represent potential landfill capacity

b) Area Method

The area method is suitable for sites where deep excavation of the soil is difficult or not desired. In its simplistic form, waste is spread and compacted in successive horizontal layers, however, such operation would not be practical and is rarely practised in such a manner.

The starting point of a landfilling operation may be compacted waste or a natural (or man-made) ramp-like topography near the edge of the site. At the working face of the landfill, incoming wastes are deposited and spread in layers, compacted and then covered at the end of each working day. Bulldozers and landfill compactors are used for spreading and compacting. Subsequently, incoming waste loads are unloaded at the toe of the preceding day's waste and pushed up and spread at the disposal face, compacted and covered. Figure 4.15 (B) illustrates an area method landfilling operation.

Compacted waste layers are typically 45 centimetres thick, but 60 centimetre thickness may be considered where heavy compaction equipment is available. Wastes can be compacted in successive layers prior to the application of cell cover. The vertical height of the compacted layers of waste at the end of the working day is normally about 2 to 3 metres

Advantages of the area method include the following:

- Unusable land can be reclaimed, and advance preparation (e.g., excavation) of the land may not be necessary;
- The high costs of excavation of a trench can be avoided;
- Weekly operating costs vary little, because there are no discrete large expenses, as in the trench method;
- Equipment requirements are generally less than the trench method;
- Depth of the water table is not as critical as with the trench method which normally requires deeper excavation.

Disadvantages of the area method include the following:

- A greater degree of wind-borne dust and debris can result unless controlled;
- The cover material will generally have to be hauled from off-site sources resulting in increased costs.

4.15.5 Winter Operations

For winter operations, advance planning for snow removal, icy access roads, staff quarters, equipment maintenance, and storage of cover materials is essential. Ground water, leachate and gas monitoring, control, containment and treatment systems should be checked more frequently. Winter problems, sometimes resulting in temporary stoppage of operations, are usually a direct result of inadequate planning and preparation.

a) Preparation of Disposal Areas

The winter disposal area should be prepared in advance, so that its capacity exceeds the expected winter waste volume. A special well-drained disposal area prepared for winter operations can minimize problems and reduce operating costs. A sunny southern exposure is often chosen, but shelter from prevailing winds and adverse weather directions afforded by hedges and trees can be more important. The capacity of the disposal area can be up to four

times that estimated, to allow for periods when waste compaction is impracticable. Waste compaction and covering is essential when conditions improve. Ponding may occur from melting snow; pumping may then be necessary to remove ponded water to established treatment or drainage systems.

Additional areas for piling snow and turning snowploughs at the disposal face and for snow disposal should also be prepared. Snow fences, to control drifting snow, should be installed. Access roads and areas leading to disposal faces should be ploughed as necessary and have a slight uphill grade, so that vehicles losing traction on ice or mud can reverse downhill to an area on which traction can be regained. Additionally, sand boxes can be conveniently available near grades on which traction may be lost, particularly when tracked equipment is not available to provide assistance to vehicles.

Ensuring surfaces that provide adequate vehicle traction is particularly important at sites without continuous supervision. It can lessen the possibility of waste unloading in undesirable, non-designated locations, and eventually, the disposal face may become inaccessible. Then, the wastes will have to be double-handled.

In some locations subject to extreme winter conditions access to the fill area may become impracticable; emergency areas are then necessary. Emergency areas, used either for disposal or storage, are usually located close to the site entrance. They should be used only when the main disposal face is not available. Access to them should be closed off, after normal operations have been resumed, by fencing and gates. Temporary signs are necessary.

b) Stockpiling of Cover Material

Excavation of the frozen ground in winter is difficult, and thus cover material should be stockpiled for use during winter operations.

The stockpile can also freeze and become difficult to use. Stockpiled soil can be protected from freezing by materials such as straw. Tarpaulins can be used to prevent the soil from becoming wet or damp, and subsequently freezing. Dangerous "overhangs" can form when material is removed from frozen stockpiles. Site equipment can be used to remove such hazards.

c) Snow Removal

Snow fencing should be installed, and arrangements for snowploughing, snow removal and snow storage areas must be made before the first snowfall. Snow fencing should be located where needs are indicated by previous experiences. Access roads should be designed so that snowploughs can operate effectively.

Areas should be prepared for storage and disposal of snow from access roads and the disposal face. They should be served by road loops, to permit additional passes, and to allow space for snowplough movement and disposal of snow from successive or severe snowstorms. In selecting snow disposal areas, spring snowmelt should be considered. Locations, from which run-off from snowmelt in spring will flow into the waste disposal areas, should be avoided. Snow fences around snow disposal areas can be very useful to collect litter during snowmelt.

d) Winter Maintenance Facilities and Practices

Winter facilities for equipment repair and maintenance, housing site personnel, provision of services such lighting and heating should be considered. A heated garage is particularly critical for equipment maintenance and overnight storage. In winter, materials become more brittle, and equipment checks to remove obstructions, such as wire and paper should be more frequent.

e) Ground Water, Leachate and Gas Monitoring, Control and Treatment Systems

More frequent inspection for proper functioning of such systems and equipment may be necessary under snowy, cold and icy conditions.

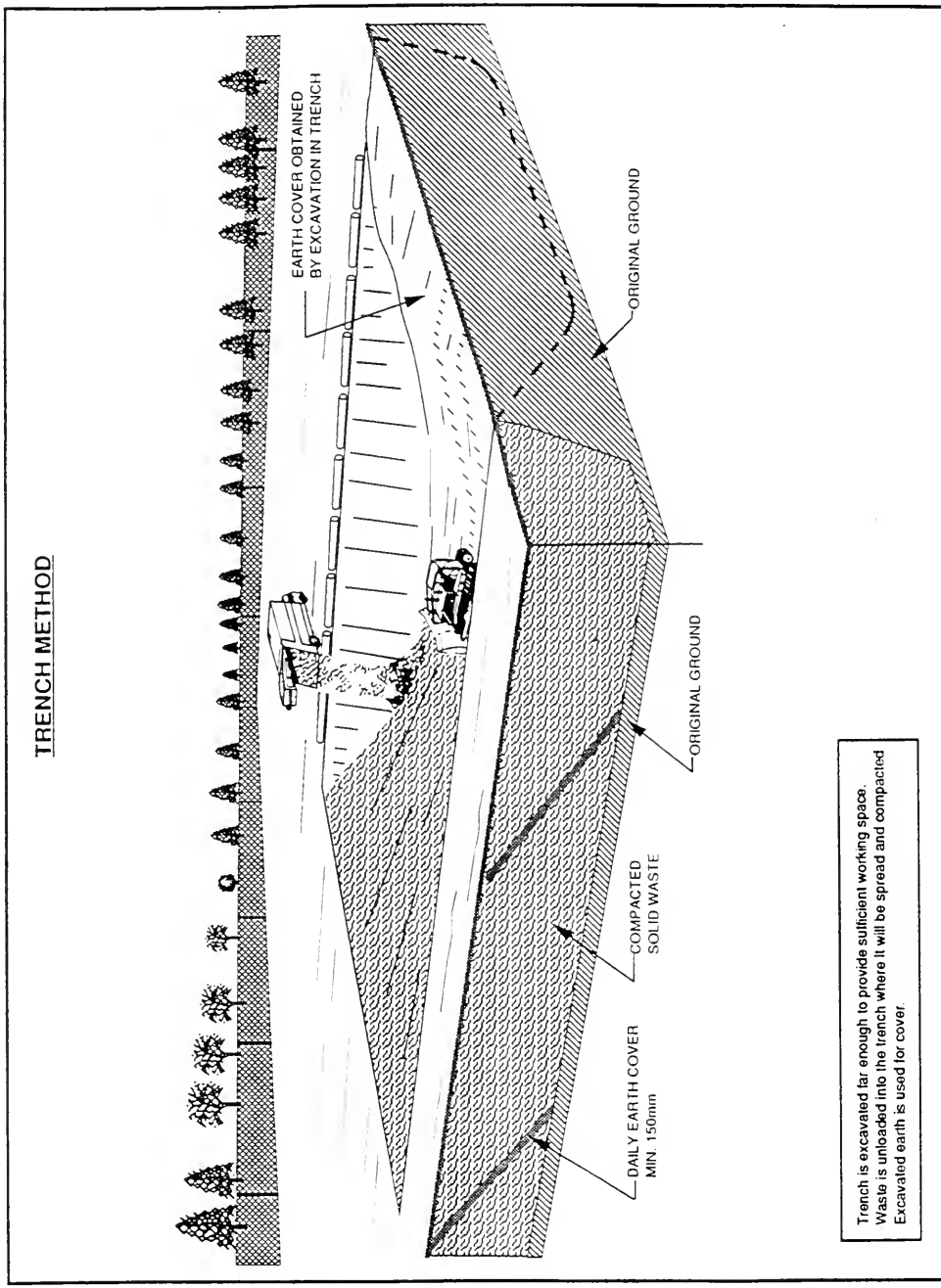

TRENCH METHOD
EARTH COVER OBTAINED BY EXCAVATION IN TRENCH
ORIGINAL GROUND
ORIGINAL GROUND
COMPACTED SOLID WASTE
DAILY EARTH COVER MIN. 150mm
Trench is excavated far enough to provide sufficient working space.
Waste is unloaded into the trench where it will be spread and compacted
Excavated earth is used for cover.

FIGURE 4.15 (A)

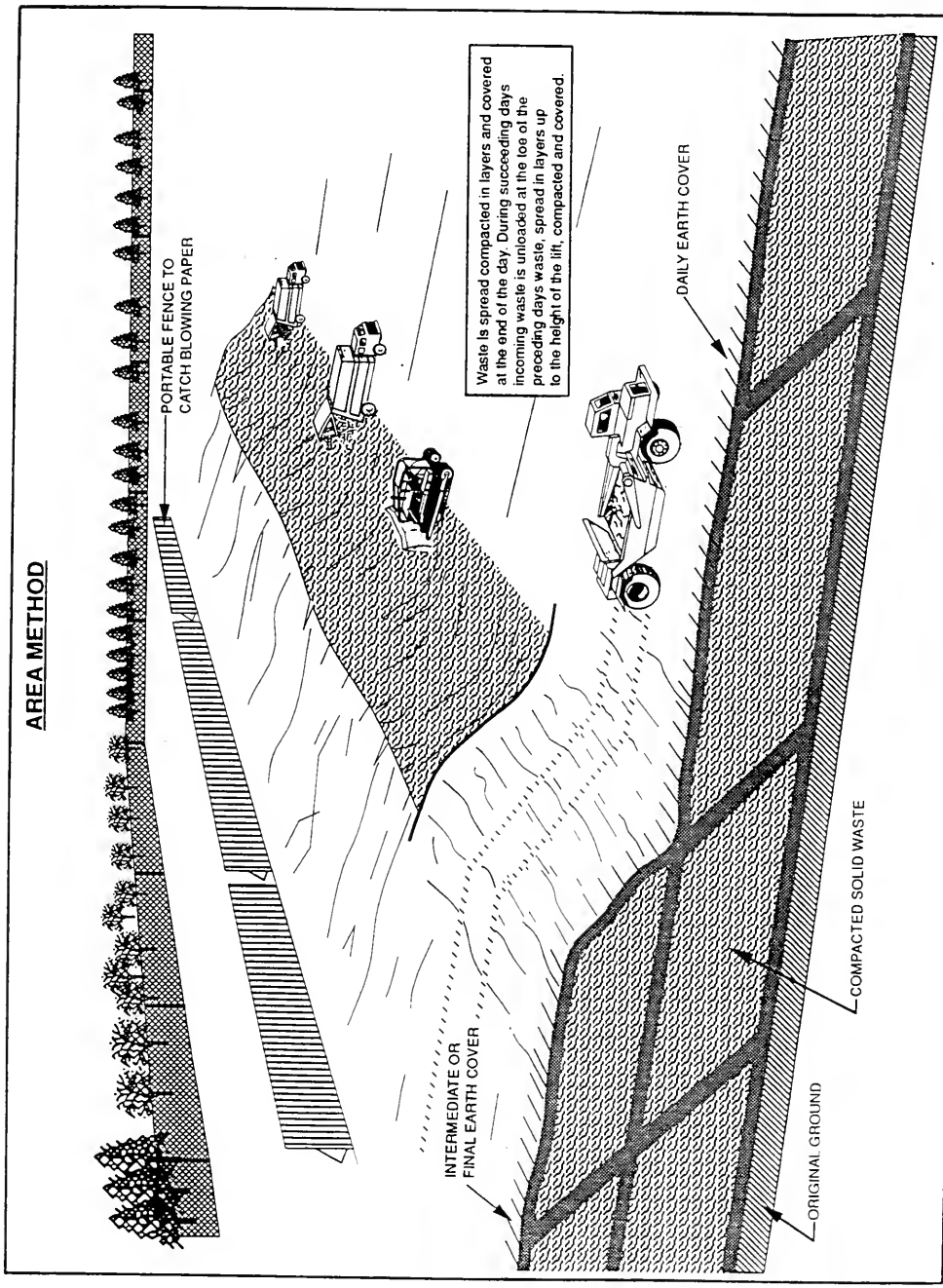

AREA METHOD
PORTABLE FENCE TO CATCH BLOWING PAPER
Waste is spread compacted in layers and covered at the end of the day. During succeeding days incoming waste is unloaded at the top of the preceding days waste, spread in layers up to the height of the lift, compacted and covered.
DAILY EARTH COVER
INTERMEDIATE OR FINAL EARTH COVER
COMPACTED SOLID WASTE
ORIGINAL GROUND

FIGURE 4.15 (B)

4.16 LANDFILL EQUIPMENT AND WEIGH SCALES

4.16.1 Rationale

Equipment and machineries are required at landfill sites to ensure that incoming waste is landfilled in compliance with site-specific approval conditions and in effective and economical manner .

4.16.2 General Requirements

a) Under Regulation 347, Section 11, adequate and proper equipment are required for compaction of waste into cells and covering the waste cells with cover material.

b) Generally, landfill sites for municipal waste require equipment to carry out the following basic functions:

a) preparation of the site;
b) handling and compaction of waste;
c) excavation and transportation of cover material;
d) spreading and compaction of daily and final cover; and
e) completion of utility work and clean-up work.

One of the most important steps in achieving efficient and effective landfilling operations is the selection of landfill equipment to effectively carry out the tasks mentioned above.

4.16.3 Equipment Selection

Careful thought and evaluation should precede equipment selection. The first consideration is usually cost, however, the cheapest equipment is not always the most economic in the long run. Each landfilling site is unique and equipment selected for specific needs can minimize operational costs. Selection of equipment should take, at least the following into consideration:

a) population served and waste quantities to be handled;
b) future population and projected waste quantities;
c) type of landfilling method;
d) weather conditions;
e) compaction requirements;
f) ancillary activities at the landfill site;
g) cover handling and hauling requirements;

h) single task or multiple task versatility required of the equipment;
i) capital costs; and
j) equipment reliability and ease of maintenance and repair.

The landfilling method, the population served and the quantity of waste handled are usually the prime considerations. Although population growth rates have, in the past, often been estimated at three percent per year, many municipalities are not growing at these rates, and rates should be determined from official plans. Per capita waste generation now appears to be stable, but recycling, reuse and reduction programs are decreasing the amounts directed to landfills so periodic monitoring is advisable. Equipment selection should be able to deal with a 25% increase in waste quantities. The site Design and Operations Plan should specify the type and number of machines which will be utilized.

The selection of numerous equipment dedicated to the landfilling site or to specific functions within the site may not be practical or affordable for the sites with smaller scale of landfilling operation. Owners and operators may consider renting or leasing equipments on an as needed basis. For municipally owned landfills, consideration may be given to sharing of equipment between landfilling and other municipal operations such as public road construction, maintenance, snow removal, sewer construction, demolition, etc.

4.16.4 Equipment Available

a) Crawler Dozers

Crawler dozers are the most commonly used machines at landfill sites. They are used to prepare land for landfilling, for spreading and compacting waste, and for ripping, spreading and compacting soil cover over refuse. These machines are versatile for all weather operations and for the trench or area methods of waste placement. Weights of crawler dozers commence at about 15 metric tonnes.

Special features available for crawler dozers include the following:

i) semi-U or full-U mould boards (blades), if large volumes of cover material are to be moved;
ii) special oversized refuse blades, for use when moving and compacting wastes;
iii) non-corrosive rubber or synthetic track seals;
iv) full track guards and sprocket inner seal guards;
v) counter-weights;
vi) engine side screens and perforated hoods; and
vii) rear mounted rippers (to break up frozen ground or cover material).

Single grouser track shoes are usually standard equipment and are effective when compacting wastes. Crawler dozers can generally achieve compaction densities of up to a maximum of about 600 kilograms per cubic metre. The best compaction densities are achieved on a 3:1 (horizontal to vertical) slope.

b) Crawler (Track) Loaders

Crawler loaders are all-purpose machines, ideal for operations at small landfill sites where generally one machine is expected to handle all the chores at the site. Their use is, however, by no means limited to small sites. Crawler loaders are best suited for trench fill operations, and compaction can be easily achieved right up to the trench walls since the bucket is no wider than the tracks. Using a general purpose or multi-purpose bucket, it can excavate, compact and transport cover to disposal faces. Crawler loaders are not efficient for moving and handling cover materials over distances in excess of about 150 metres.

Bucket capacity used usually ranges from 1.5 to 3 cubic metres. Four cubic metre buckets are used occasionally. When large objects, such as appliance bodies and tree stumps, are handled or crushed, multi-purpose buckets may be employed.

For waste handling operations, single grouser track shoes provide better cutting action. Large machines should have 3-bar semi-grouser shoes to prevent track damage during turning. Weights commence at about 12.5 metric tonnes. Special features available in crawler loaders include the following:

i) non-corrosive rubber or synthetic track seals;
ii) full track guards;
iii) sprocket inner seal guards, to reduce the risks of damage by wire;
iv) counter-weights to aid in compaction; and
v) a rear mounted ripper, to break up frozen cover material.

Crawler Loaders can achieve refuse compaction densities up to a maximum of about 600 kilograms per cubic metre.

c) Wheel Loaders

Wheel loaders are versatile machines and their particular advantage is mobility. Wheel loaders are not recommended to be used for compaction purposes at a landfill site. They are generally used for loading trucks with cover material or recyclable material, carrying waste and performing general clean-up chores.

Steel guard tires, to prevent flats, are desirable for equipment working over wastes. Radial tires are often vulnerable to side-wall punctures and foam filled tires are sometimes used.

Guards can prevent wire from tangling in drive shafts. Multi-purpose buckets add versatility to wheel loaders.

Weights commence from about 6.5 metric tonnes and bucket capacity ranges from about 3/4 cubic metres to 10.5 cubic metres for the largest type of wheel loader available.

Wheel loaders can achieve compaction densities comparable to those achieved with track type machines. However, due to the possibility of tire failure from punctures, wheel loaders are not used to compact waste.

d) Steel Wheel Landfill Compactors

Landfill compactors are specialized machines equipped with dozer blades or buckets and steel, drum-like wheels that have specially arranged steel teeth, welded onto the outer surface of the wheel. Their function at the landfill site is to spread, compact and cover large volumes of incoming waste. The weight of the machines and the action of the wheels combine to tear and crush refuse and increase landfill capacity considerably by providing greater efficiency in compaction. There are also several other significant benefits in employing steel wheel compactors at landfill sites:

i) Reducing percolation of moisture through refuse by achieving greater compaction, thereby reducing leachate production;
ii) Reducing fire risk by drastically reducing air voids in refuse through effective compaction;
iii) Reducing incidence of rodents, vectors and odours by eliminating loose refuse and air voids that provide breeding ground for unwanted pests; and
iv) Reducing extent of settlement of the landfill.

Steel wheel landfill compactors are faster and more mobile than crawler dozers and track loaders and achieve considerably higher compaction densities. These machines are more commonly used at larger landfill sites. Operationally, they may be equally suited for use at small landfill sites and the return, in terms of increased landfill life, may justify the capital cost incurred in providing such a machine which can be used only for landfilling activities, unlike track loaders or crawler dozers.

Landfill compactors are most effective on relatively flat surfaces and their compaction efficiency diminishes on slopes steeper than 4:1 (horizontal to vertical). Landfill compactors cannot excavate cover, but can move, spread and compact cover material.

Compactors with four wheels provide greater compaction with fewer passes since wheels track each other, providing double coverage in one pass. Landfill compactors with weights in excess of 20 metric tonnes are capable of achieving refuse densities ranging from 700 to 950 kilograms per cubic metre.

Other special features that could be provided are four wheel drive and oscillating rear axles for stable manoeuvring on slopes with effective compaction, and articulation which permits tighter turns in confined spaces and is ideal for trench fill operations.

e) Wheel Tractor Scrapers

Wheel tractor scrapers are principally used on large landfill sites. They are not used for handling refuse and are designed to excavate and haul cover material economically at distances over 200 metres. They are capable of spreading cover in thin, uniform layers, can climb steep grades with ease and can travel quickly over rough haul roads. They are also utilized for excavating trenches in preparation for landfilling.

Four types of tractor scrapers are used at large landfill sites:

i) Conventional scrapers that require a pusher tractor - usually those with larger capacities are more economical and recommended;

ii) Elevating or self-loading scrapers - these scrapers are particularly useful since they do not need to be push loaded; however, their excavating capability is reduced in adverse soil conditions;

iii) Self-loading auger scrapers - these machines are preferred in adverse soil conditions and can quickly and efficiently move large amounts of earth or cover by combining tandem power and self-loading capabilities; and

iv) Push-pull or twin-hitch scrapers - two all wheel drive scrapers assist each other to load without the use of pusher tractors. Scrapers are equipped with special push blocks and coupling devices. Such machines are not widely used at landfill sites unless the operation includes long, straight hauls and relatively easy to load material.

Although scrapers are not normally used directly over wastes, wastes can be compacted further through repeated passes during waste covering operations. Scraper tire damage can be reduced by limiting travel over compacted waste that may contain wire, metal and other sharp objects. A "strike-off" blade, which levels dumped materials, may be used for grading.

Empty weights commence at about 12 metric tonnes with heaped bowl capacity ranging from 7.5 to 23 cubic metres for a single tractor scraper.

f) Other Support Equipment

i) Motor Graders

These are generally used primarily to grade and maintain haul and access roads and for snow cleaning. They are also used for shaping drainage ditches, preparing final grades

and grading final cover in preparation for vegetation. Generally, smaller sized graders are employed.

ii) Backhoe Loaders

These are useful for constructing and maintaining ditches, for cleaning out drainage works, and for moving and loading single articles of waste.

iii) Integrated Tool Carriers

These are excellent utility machines which are used for various landfilling operations. With the option of numerous special attachments, these machines have proven to be invaluable at landfill sites of all sizes. Some of the special attachments that are particularly useful for landfill operations are

- general purpose buckets for loading, carrying and stockpiling material;
- multi-purpose buckets for stripping topsoil, cleaning-up debris, etc.;
- utility pallet forks for handling baled waste;
- claws for garbage pick-up and cleaning up; and
- material handling arms for handling bulky, non-palletized material, prefabricated building panels, etc.

iv) Articulated Dump Trucks

For hauling cover material from any distance, articulated dump trucks are versatile, all-weather haulers with good manoeuvrability which are well suited to negotiate poor under-foot conditions.

v) Winch Attachments

These have value because they can be used to remove immobilized dozers, loaders and trucks, which can disrupt disposal area traffic.

vi) Water Trucks

Water trucks are very useful for any landfill site. They can be utilized for controlling dust on access and haul roads and at the disposal face. Equipped with high pressure capacity, they can be used for putting out small fires and for washing equipments and machines.

vii) Hydraulic Excavators

These machines are occasionally used to excavate small trenches in trench fill operations. They are more commonly used at landfill sites in the maintenance and clean-out of drainage ditches and structures, and in the laying of drainage and leachate collection piping. Hydraulic excavators are also used to handle and load waste drums.

Typical machineries used for landfill site work are illustrated in Figures 4.16 (A), (B), and (C).

4.16.5 Equipment Maintenance

New, well maintained equipment is typically trouble free for at least two years. However, the site operator should have ready access to standby equipment for periods when equipment is undergoing maintenance or repair. Difficulties with equipment during freezing conditions and in hot or wet weather should not occur where equipment care and maintenance are adequately planned and implemented. Operations and maintenance manuals for all site equipment, including heavy construction equipment, should be available to the site operator.

Equipment should be checked each day using a maintenance check-list. Radiator plugging is a frequent occurrence for landfilling vehicles. When radiators are front mounted, side screens and perforated hoods help prevent engine overheating. When radiators are rear mounted, these problems occur less frequently. Waste disposal operations, particularly in winter, are extremely hard on equipment. Periodic inspections during each working day, for example to remove wire and paper from rollers, radiators, belly skids, idlers and sprockets, are required. In addition, the necessary daily checking and maintenance routine normally includes

a) complete mechanical checks at the end of each working day;
b) checking belts and liquid levels in radiators before starting;
c) idling the engine for five minutes before moving, particularly in winter;
d) checking that all rollers are moving;
e) recording actual items checked; and
f) recording running time, and repair work executed.

4.16.6 Equipment Selection Based Upon Waste Tonnage

A guideline on equipment selection based upon daily waste quantities is given below. These suggestions are general, and it is essential to consider all site-specific conditions and requirements in finally selecting landfill equipment. A Community practising waste reduction, reuse and recycling will have reduced waste tonnage than described below.

a) Population 15,000 - 40 tonnes of waste per day.

1 Crawler Loader - 1 cubic metre bucket

b) Population 20,000 - 55 tonnes of waste per day.
1 Crawler Loader - 1 1/3 cubic metre bucket

c) Population 40,000 - 110 tonnes of waste per day.
1 Crawler Loader - 2 cubic metre bucket or
1 small Crawler Dozer plus
1 Wheel Loader - 2 cubic metre bucket

d) Population 60,000 - 160 tonnes of waste per day.
1 small Crawler Dozer, plus
1 self-loading 17 cubic metre bucket tractor scraper, plus
1 Crawler Loader - 2 cubic metre bucket or
1 steel wheel landfill compactor (16 metric tonnes) with multi-purpose bucket.

The small crawler dozer would spread and compact the waste, while the tractor scraper would excavate an adjacent trench and/or haul cover material. The larger crawler dozer would spread and compact cover material and grade finished areas. A Steel Wheel landfill compactor can be used to spread and compact waste; a larger Crawler Dozer can serve as a back-up unit for this work.

e) Population 150,000 - 400 tonnes of waste per day
1 Crawler Dozer or
2 Self-loading 17 cubic metre bucket tractor scrapers, plus
1 Steel Wheel landfill compactor (16 tonnes) with multi-purpose bucket

f) Population 200,000 - 540 tonnes of wastes per day
1 larger Crawler Dozer, plus
2 Self-loading 17 cubic metre tractor scrapers, plus
2 small Crawler Dozers, or
1 Steel Wheel landfill compactor (22 tonnes) with multi-purpose bucket.

4.16.7 Scale Facilities

Weighing incoming waste is one of the means of obtaining reliable information to determine current and future landfill needs. Weighing also provides an equitable basis for establishing tipping fees. It also provides data necessary to check the density of waste cells.

Incoming waste is weighed on a truck scale located usually at the entrance to the landfill site. An adjacent scale house provides housing for the site personnel responsible for checking,

recording, registering and charging tipping fees, and also provides housing for weight indicators and data recording devices.

There are basically two types of truck scales installed at landfill sites for weighing incoming waste. They include *pit scales* - with scales installed in a pit which requires significant excavation, with the weighing platform installed level with the ground; and *pitless, above ground scales* - with ramps up to the weighing platform thereby necessitating less excavation.

Landfill truck scale consists of three basic components:

- The weighing platform portion which receives the load (either at or above ground level as described above) usually of steel, timber or concrete construction, supported by mechanical levels or electronic load sensors mounted under the platform frame.

- The weight indicator which is usually a mechanical weigh beam indicator or an electronic indicator. Digital indicators are used for convenience.

- The data recording device which range from simple devices attached to mechanical weigh beams providing mechanical print out on pre-printed ticket form, to more sophisticated devices such as computers, printers, and remote weight displays.

There are numerous factors to be considered in selecting the most suitable scale facility for a landfill site, and some of the more significant are listed below.

i) Space available for scale facility and traffic routes entering and leaving the landfill site.

ii) Proposed truck traffic - number of trucks expected to be waiting in line to enter at peak times, and cross traffic needs. One-way traffic is recommended over the scale even in low traffic situations with outbound traffic using separate lanes.

iii) Frequency of use - regular, periodic or occasional use. Scale facilities at small sites may be difficult to justify considering the cost, especially, if they will only be used occasional.

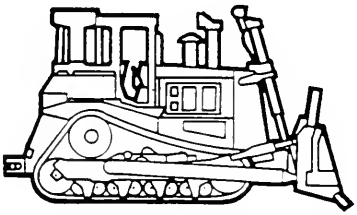
iv) Permanence of installation - short-term or long-term. Pit scales are considered permanent and cannot be relocated, whereas pitless above ground scales can be relocated with relatively lower foundation costs.

v) Subsurface conditions - will determine the feasibility of installing either pit or above ground scales. Foundation requirements, buried utilities, obstructions such as rocks and frost penetration depth must also receive due consideration.

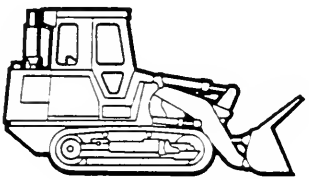
vi) Snow accumulation and ice build-up with associated maintenance considerations - elevated platforms require side rails which make snow removal troublesome. Ice build-up between the foundation and scale understructure can cause inaccurate weights or can even immobilize the scale completely.

vii) Cost - cost of installation and maintenance and degree of sophistication (mechanical, electromechanical or fully electronic).

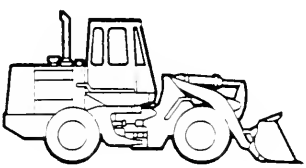
TYPICAL MACHINERY USED FOR LANDFILL SITE WORK



CRAWLER DOZER
(SPECIAL ATTACHMENTS USED REAR MOUNTED RIPPERS, LANDFILL (TRASH) BLADES)



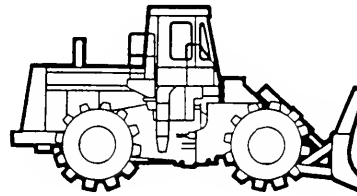
CRAWLER (TRACK) LOADER
(SPECIAL ATTACHMENTS USED: REAR MOUNTED RIPPERS , LANDFILL (TRASH) BUCKETS)



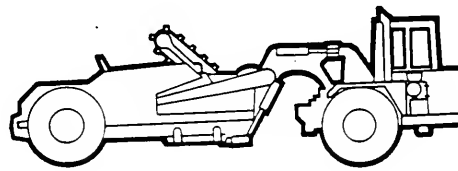
WHEEL LOADER

FIGURE 4.16 (A)

TYPICAL MACHINERY USED FOR LANDFILL SITE WORK



LANDFILL COMPACTOR
(COMPACTORS WITH TWO OR FOUR COMPACTING WHEELS ARE AVAILABLE)

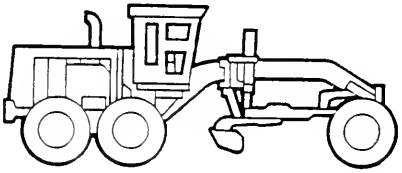


WHEEL TRACTOR SCRAPER

BACKHOE LOADER

FIGURE 4.16 (B)

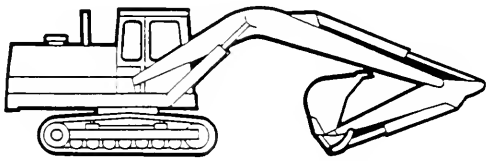
TYPICAL MACHINERY USED FOR LANDFILL SITE WORK



MOTOR GRADER

INTEGRATED TOOLCARRIER

SPECIAL ATTACHMENTS USED : MULTI-PURPOSE BUCKETS, PALLET FORKS, CLAWS AND MATERIAL HANDLING ARMS



HYDRAULIC EXCAVATOR

FIGURE 4.16 (C)

4.17 CELL COVER - DAILY AND INTERMEDIATE COVER

4.17.1 Rationale

The purpose of cell cover is to control insects, rodents, scavenging by birds, blowing litter, fires, odours, provide better access to the working face and to maintain an aesthetically pleasing site appearance. The intent is to ensure that deposition of waste will not adversely affect the environment and public health while the site is in operation.

4.17.2 General Requirements

a) Regulation 347, Section 11 specifies that waste deposited in a landfill shall be covered with cover material.

b) The site Design and Operations Plan should include details of the type of cover materials, where the cover material is to be obtained, and how it is applied to the fill area. These should be based on site-specific evaluation of soil conditions and operating methods and equipment.

The active face of landfill sites should be covered daily, or whenever the site is being operated, if not on a daily basis. For small, isolated or seasonal sites, daily cover may not be required and less frequent applications, such as weekly or monthly, may be acceptable due to infrequent usage or the nature of the waste. Where waste is pre-processed by methods such as baling, the requirement for cell cover are determined on a site specific basis.

c) The difference between daily and intermediate cell cover is basically the frequency and thickness of application. Daily cover is applied on a routine basis each day a site is operated, while intermediate cover is applied to areas which will not receive additional wastes for periods in excess of several weeks or months.

d) The minimum thickness of daily soil cover is 150 millimetres. Intermediate soil cover thicknesses are normally considered adequate at 300 millimetres.

4.17.3 Soil Cover

a) Normally, landfill design will incorporate a cut and fill calculation that will predict the quantity of cover material to be used during the active life of the site. A general rule for the waste to cover ratio, including intermediate and final cover, is four parts waste to one part cover by volume.

b) Soil texture determines some of the properties of daily cover after it has been applied. For example, fine grained soils will tend to trap gases and cause ponding of precipitation during the life of the site. Once the site is closed, the fine grained soils could promote perched leachate conditions resulting in side slope discharge (breakout) of leachate. Daily scarification of fine grained cover during landfill operation will help minimize this long-term difficulty.

Course grained soil on the other hand, will allow precipitation to infiltrate readily to the base of the landfill. However, the difficulty which may arise with use of non-cohesive soils as daily cover is that rainfall and vibration (due to equipment and vehicle movement over the landfill) may result in the downward percolation of the cover into the refuse. Frequent re-covering of fill areas may be required to provide an aesthetically pleasing appearance. The process of re-covering areas of the site will also affect the quantity of material used, possibly resulting in a net deficit of cover material.

c) Daily cover should be stored in a manner that will promote its efficient use. During winter operations, coarse grained soils are usually more suitable than fine grained soils. Fine grained soils cannot readily be excavated and used for cover in cold weather. In all cases, efficient use and application of cover material requires that minimum handling of the soil is undertaken, i.e., minimize double or triple handling, and that the underlying wastes are well compacted.

4.17.4 Other Sources of Cover Materials

a) Appropriate waste material or material other than soil can be approved as an alternative material for daily or intermediate cover. If the alternative cover material is a waste, it must quality as non-hazardous under Regulation 347.

MOEE will require field trials to be undertaken at the landfill on an experimental basis and require evaluation of the material's suitability as a cover material. Permission to conduct the trial must be obtained from the MOEE. An amendment to the Certificate of Approval is normally required to allow the trial or on-going use of the alternative material.

b) Synthetic foam cover may be considered as an alternative to daily soil cover where approved by the MOEE. Use of foam may be desirable where soil is scarce or unavailable on or near the site or where landfill volume conservation is crucial. The concerns for potential impact of the foam on leachate quality and use in severe weather conditions however would need to be addressed. Synthetic foam cover thickness will be variable and in accordance with the manufacturer's recommendations and will normally decompose to insignificant thicknesses. Cell cover thickness may vary from that suggested, depending on site conditions and operating methods, but the intent of

reducing nuisance effects must be achieved. The use of foam should be assessed on a case-by-case basis by the proponent in terms of both suitability and cost considerations.

b) Used foundry sand from foundry operation is an example of a waste material which may be acceptable for use as a daily or intermediate cover material at landfill sites to supplement other sources of cover, subject to MOEE approval.

c) Wood chips which are produced when wastes, such as pallets, stumps, construction wood, are shredded have often been considered to be a possible daily cover material particularly when the end product is not marketable for landscaping, erosion control or other applications. However, there is concern that if used as a cover material, wood chips could pose a fire hazard particularly if "hot loads" of refuse are landfilled on top of them.

d) Certain mine tailings, stabilized and dewatered sewage sludges, off quality compost or paper sludge could also be considered for potential use as daily cover pending the requirements outlined in (a) above.

4.18 SUPERVISION

4.18.1 Rationale

Site supervision and inspection are required to ensure orderly and safe operations at the landfill site and to ensure that all waste handling and disposal operations are carried out in accordance with the Certificate of Approval, the supporting Design and Operations Plan and applicable regulations. Supervision of site admission is particularly important to ensure that unacceptable wastes are not accepted.

4.18.2 General Requirements

a) Ontario Regulation 347, Section 11 stipulates the following standards related to site supervision:

   i) Access to the site shall be limited to such times as an attendant is on duty and the site shall be restricted to use by persons authorized to deposit waste in the fill area;

   ii) All waste disposal operations at the site shall be adequately and continually supervised; and

   iii) Procedures shall be established, signs posted and safeguards maintained for the prevention of accidents at the site.

b) Landfill sites can receive wastes for which approval has been granted through the Certificate of Approval. The waste hauler or generator should provide sufficient information to the landfill operator for determining the eligibility of the waste (load) for disposal at the site. Prior to acceptance, the landfill operator shall take the necessary steps to enable this determination.

c) A role of the site supervisor is to ensure compliance of the landfill site with all applicable regulations, including all aspects of Regulation 347. Hazardous and liquid industrial wastes, defined in Regulation 347, are not permitted for disposal at landfill sites approved for municipal waste. However, it is recognized that municipal waste may include residual amounts of pharmaceuticals, cleaning products, paints, etc. that are used and discarded from households.

4.18.3 Incidents Requiring Immediate Response

Incidents requiring immediate response by the landfill operator include landfill fires, methane gas related explosions, spills, identification of materials not permitted on-site, improper handling by the hauler of acceptable wastes such as asbestos and non-hazardous hospital wastes, personnel injuries, vehicle accidents, and failure of on-site equipment.

The responsibility of planning for and responding to these incidents and emergency situations rests with the site owner and operator. Staff should be trained to deal with each emergency so that minimal health, safety, or environmental impacts occur. For serious incidents, the police, fire department, MOEE, local health departments, or the Ministry of Labour may require immediate notification.

The site operator should provide planned actions for all potential incidents of this nature prior to commencement of waste disposal. The emergency responses should clearly identify the action to be taken, the person to undertake the actions, discuss the need to advise appropriate authorities, and provide telephone numbers of the authorities to be contacted.

All emergency response equipment, such as fire extinguishers, should be checked routinely and kept in good operating condition.

4.18.4 Supervision and Inspection of Landfill Site Operations

It is essential that the operational activities of the site staff and the users of the site are supervised and the site regularly inspected for adherence to the Design and Operations Plan. The site facilities and equipment should be regularly inspected for proper functioning. Good housekeeping measures can reduce the nuisance impacts such as noise, dust, litter, odour, vectors, scavenging birds and animals and are discussed in Subsection 4.20.

a) Inspection of Site Approaches

The approaches to and areas outside the landfill site boundaries should be regularly inspected for wind-blown litter from the site or inadvertently dropped litter from waste hauling vehicles. A regular program should be undertaken to inspect for intentionally discarded wastes along the route to the landfill so that the parties responsible can be required to collect their material and dispose of it properly.

b) Admission to the Site

The first supervision item is the control of admission to the site. Regulation 347 stipulates that the waste disposal area shall be enclosed to prevent entry by unauthorized persons and access to the property shall be by roadway closed by a gate capable of being locked. Accordingly,

the first duties of the gate attendant or scale operator (where applicable) are to obtain sufficient information about the origin and type of wastes. This information as well as any other supporting information form the basis for determining the acceptance of the waste and the privilege of site access for the waste hauler.

The gate attendant should request at the least the following information from waste haulers entering the site:

- Certificate of Approval number;
- sources and types of wastes;
- account number (for administrative convenience); and
- vehicle licence number.

Members of the public hauling their own household wastes to the site do not require a Certificate of Approval, but should be questioned to identify the waste or to ensure that they have not brought unacceptable wastes to the site.

Keeping accurate records on incoming waste amounts can assist in accurately determining the current and future landfill needs. Weighing the waste, through weigh scales at the site entrance, is one method of gathering this data. Weighing also provides one of the mechanisms for establishing tipping fees.

A scale facility for a small landfill may not be justified economically. Nonetheless, gathering information about the amount of incoming waste is essential. One alternative at a small landfill is counting the incoming vehicles. This is, at the best, a gross estimate of incoming waste quantity due to the variance in capacity of different vehicles, partial loads and the different densities of the loads.

c) Working Face

Procedures to follow at the working face should be clearly understood by all users. This is best accomplished by one or more "spotters" for directing loads at the working face and being alert to unsafe circumstances that may lead to accidents. Signs at the working face also can provide directions.

The landfill staff should also have a clear understanding of their role and duties - this is the task of the supervisor. The responsibilities of the site staff can include establishing the waste cells by directing waste placement, compaction of waste and maintaining the dimensions and elevations of the lifts, etc. The degree of waste compaction achieved should be periodically assessed as greater compaction will generally extend the life of the site.

The adequacy of the daily cover or interim cover should be regularly inspected as it has great bearing on the nuisance factors such as wind-blown litter, odour, vectors and vermin. Other measures also may be needed to control these nuisance factors (e.g., litter fences).

d) Engineered Facilities

Engineered facilities should be regularly inspected for proper functioning. Engineered facilities include synthetic and/or earth liners beneath a landfill; synthetic and/or earth covers; leachate collection systems; leachate treatment systems; gas interception, collection and venting systems; facilities for the control of contaminated surface water or ground water; facilities for "rapid stabilization" of the landfill; and monitoring systems for ground and surface water and for gas. The environmental control works and monitoring equipment may require maintenance, adjustment, repair or replacement if they fail to operate within the limits set at the design and commissioning stages of landfill development.

Leachate collection systems are now common throughout Ontario at larger landfills. Landfill gas collection systems are less common, but both systems require inspection for possible accumulation of combustible and explosive gases from the decomposing wastes.

Sediment control features have been provided at some landfills to control suspended solid transport in storm run-off. It is necessary to regularly inspect all components of the surface drainage system and to undertake any remedial measures found to be necessary.

e) General Site Conditions

Throughout the operating life of the landfill site, it is necessary to regularly inspect the general conditions within the buffer area. This can include checking the condition of roads, buildings and site fences; presence of odour; erosion and sedimentation; vegetation failure; and especially any wind-blown litter.

The disposal areas completed to final elevation and final cover established should be inspected for areas of unusual settling or subsidence, leachate breakout, erosion of cover and stability of vegetation. In some case, automotive tires may have "worked" to the surface of the landfill.

The excavated areas should also be inspected for erosion of slopes and ponding of water.

f) Landfill Capacity Assessment

The quantity of waste in place should be checked against the approved landfill capacity throughout the landfill's active life to determine the remaining landfill capacity. This may entail density checks to determine the degree of compaction achieved; elevation surveys of the waste disposal area to develop cross-sections for calculating waste volume; and settlement determinations which show the consolidation of the waste under its own weight. This latter

phenomenon should be monitored regularly to show the actual site life remaining, as the nominal capacity is neared.

i) Inspection Report and Record Keeping

At all landfill sites, it is advisable for the supervisor to maintain a monthly report on all of the foregoing supervision items. The report will serve to document site development and the steps taken to conform with regulatory and operational requirements.

Requirements for record keeping depend on the daily waste quantities and the type of equipment used. Good initial planning helps to ensure effective co-ordination of operations and equipment use. Good record keeping is an essential adjunct for cost optimization. Although records need not be elaborate, they should permit the calculation of full costs of operations. It can include items such as man-hours worked, equipment maintenance and down-time, cover material used, grading time, litter control and trenching, etc.

The landfill site owners and operators are encouraged to maintain a cost record on all equipment. The cost record should cover the purchase price, and the cost per hour of operation (i.e., fuel, labour, maintenance). It should also include estimates of equipment depreciation and trade-in price.

Records help in identifying areas of inefficiency, ascertaining reasons for cost increases and planning corrective actions. They also permit future costs to be predicted and appropriate charges to site users to be calculated.

4.19 HANDLING OF OTHER WASTES

4.19.1 Rationale

Special handling and disposal procedures are necessary for certain wastes not regularly disposed of at municipal waste landfill sites in order to ensure compliance with regulations and the Certificate of Approval. Special procedures for problematic wastes can help ensure efficient disposal practices, and reduction of nuisance, health and safety concerns.

4.19.2 General Requirements

a) Rejection of Wastes From Landfill Disposal

Generally, waste may be refused at a landfill approved for municipal waste due to one of the following:

i) Non-conformance with the Act or regulations;
ii) Non-conformance with the Certificate of Approval (i.e., lack of site approval to receive that particular waste type); or
iii) Non-conformance with the landfill's own policy (e.g., pursuant to a ban on drywall, refusal to accept metal drums, loss of disposal privileges by the waste hauler due to poor waste handling practices).

Ontario Regulation 347 provides definitions for wastes, including liquid industrial wastes and hazardous wastes, which help in interpreting conditions in the Certificate of Approval. Although hazardous and liquid industrial wastes are not prohibited specifically by regulation from disposal at municipal waste landfills, the conditions of the Certificate of Approval are used to specify acceptance of domestic, non-hazardous or like wastes and prohibit acceptance of hazardous and liquid industrial wastes.

Additionally, certain wastes may be rejected as a matter of the landfill owner's own policy. For example, metal drums are typically refused due to the potential of containing hazardous or liquid wastes. Similarly, materials targeted for recycling such as drywall or corrugated cardboard may not be accepted in an effort to promote recycling.

There are those wastes which are appropriate for disposal at the landfill, but problematic due to operational concerns related to nuisance or health and safety. Procedures to handle such problematic wastes should be described in the Design and Operations Plan.

b) Generator Registration and Manifest Requirements for Hazardous and Liquid Industrial Waste

The generator registration and manifesting requirements, as specified under Regulation 347, help to ensure that hazardous and liquid industrial wastes are not disposed of at municipal waste landfills.

All industries, commercial establishments and institutions in Ontario are required to identify wastes that they generate, to determine if they are hazardous or liquid industrial wastes, and if so, to registered with the MOEE. This process of registration also provides a mechanism for the waste generators to determine if their wastes are eligible for acceptance at landfill sites approved for municipal waste. If the landfill operator has any reason to suspect that a received waste load/material is erroneously identified as non-hazardous solid waste, the landfill operator should request the waste generator or hauler to provide proof or test results.

The manifesting requirement for hazardous and liquid industrial wastes also helps ensure the diversion of hazardous and liquid industrial wastes from municipal waste landfills. It is the legal responsibility of the waste generators to use MOEE approved haulers and receivers, and for hazardous or liquid industrial wastes, haulers must in turn ensure that the generator is registered with the MOEE and that the designated receiver is approved by the MOEE. The documentation passing from a generator to a hauler and finally to a receiver and annotated by each, forms the basis of a comprehensive tracking process of the movement of hazardous and liquid industrial wastes. The tracking process is made possible by the use of a manifest, as specified by Regulation 347, with six copies, including two from the waste generator and recipient, that are sent directly to the MOEE at appropriate stages.

4.19.3 Handling of Specific Wastes

Certain municipal waste may be appropriate for disposal at the landfill, but operationally problematic due to nuisance or health and safety concerns. Procedures to handle problematic wastes should be described in the Design and Operations Plan. The handling of wastes at landfill sites **must be in compliance to the respective Certificates of Approval** and its supporting document, the Design and Operations Plan. Some of the procedures described below, such as the use of contaminated soil as cover material, may require amendment to the Certificate of Approval.

a) Sewage Sludge

Sewage sludge from either public or private sewage treatment plants may be accepted for disposal at landfills accepting municipal waste.

For the disposal of such a waste at a landfill, it is necessary to provide certain precautions. The sludge should be accepted early in the operating day and progressively covered with double the normal thickness of soil or other suitable material.

The specific requirements should be worked out for each source of sludge as to whether or not stabilization, digestion or dewatering will be carried out prior to disposal.

b) Non-Hazardous Incinerator Ash

Ash resulting from the incineration of domestic waste or other waste of a similar nature should be handled in a manner that prevents the fine material from becoming air-borne. It should be covered immediately following placement by a cover layer of soil of minimum 100 millimetre thickness.

It should be noted that the fly-ash (particulate matter removed from the flue gases) or the incinerator ash from incineration of hazardous or liquid industrial waste should be verified as being non-hazardous prior to receipt.

c) Contaminated Soil

Provided that a contaminated soil does not produce a leachate, containing any of the contaminants listed in Schedule 4 of Regulation 347 at a concentration in excess of one-hundred (100) times that specified in the Schedule (using the prescribed Leachate Extraction Procedure), it is not a leachate toxic waste. If a contaminated soil can be demonstrated as being non-hazardous waste, which excludes leachate toxic waste, possible uses of such soil at landfill sites may be considered on a site-specific basis.

Contaminated soils with leachate concentrations less than 100 times Schedule 4 values have been brought to landfills for disposal and have taken up valuable space as wastes, even though the material may perform well as cover material. Such contaminated soil could be stockpiled on previously landfilled area for later use. On a case-by-case basis, the contaminated soil may be used as is or blended with clean cover material. It may be used for interim or daily cover.

d) Asbestos Waste

Regulation 347, Section 17 provides specific provisions for the management of asbestos waste. These provisions describe packaging requirements, signing, transportation precautions, conditions of deposit at landfills, immediate covering of the deposited asbestos waste with at least 125 centimetres of garbage or cover material, personal protective clothing requirements, requirement for supervision, and the need for precautions to prevent asbestos waste from becoming airborne. References should be made to the detailed requirements for asbestos waste described the Regulation.

e) Carbon Black Waste

Although carbon black is not toxic, the material presents a nuisance and close supervision of disposal is often required to ensure that the very fine particles do not become airborne. Disposal of carbon black at a landfill should only be allowed in the absence of wind conditions.

Disposal can be carried out at a cut into the tipping face at a landfill. A polysheeting tent is constructed around the rear of the vacuum truck (by the hauler) and extended outward to control the disposal of the carbon black waste. After the tent is secured, the vacuum truck can release its load of carbon black into the tented enclosure. When unloading is complete, the polysheet is removed and secured over the carbon black at the landfill. General landfill waste is then to be put over the polysheeting and the carbon black thereunder to further minimize the possible emission of carbon black into the air.

The personnel who are involved in the preparation and disposal are advised to wear half face particle respirators and protective clothing.

f) Food Processing Waste

The normal practice in the food processing industry is to separate solids, such as rejects and trimmings, to allow for reuse in food by-products, animal feed, soil conditioning purposes or to permit ease of disposal. Only after the screenings have passed the by-products recovery program should they be brought to a landfill site for disposal.

g) Municipal Leaf Collection Wastes

The best way to deal with municipal leaf collection wastes is by way of composting, rather than disposal. As indicated in the foregoing subsection, it may be possible to mix nutrient-rich food wastes with leaf wastes as part of a successful composting operation at landfill sites.

In some circumstances, the disposal of municipal leaf collection wastes may provide an opportunity for mixing with, and the disposal of, such problem materials as wire fencing which would otherwise present risks of damage to the tread and axles of site equipment.

h) Separation of Incompatible Wastes

Waste materials such as white goods (kitchen appliances), scrap metal, wires, logs, brush and construction wastes can be temporarily stored, each in a separate area. Recycling of these and other waste materials can save landfill space. Additionally, other uses may be realized; for example, logs, brush and construction wastes can be used to assist in wire disposal, or construction debris such as bricks can be used for on-site roads.

The best way to deal with white goods is through a metal recycling program with CFC (chlorofluorocarbon) recovery. Where there are no reasonable means to recycle, and disposal is being considered, the white goods should be crushed to enable more compact shapes to be buried in the landfill.

4.20 HOUSEKEEPING

4.20.1 Rationale

The intent is to protect the public and surrounding environment from nuisance effects and to minimize these nuisance effects by adopting housekeeping measures as part of the landfill operations. Good housekeeping practices will also enhance public perception and acceptance of the landfill.

4.20.2 General Requirements

a) A well thought out plan and implementation of good landfilling practices will control the nuisance factors and negative image of landfill sites to a considerable extent. Regular housekeeping is essential to control such nuisances as:

i) noise;
ii) dust;
iii) litter;
iv) odour;
v) rodents, insects and other disease vectors;
vi) scavenging birds; and
vii) bears, as experienced at many sites in northern Ontario.

b) The Regulation 347, Section 11 requires landfill site owners/operators to establish procedures for the control of rodents and other animals and insects at the site. They, however, should take note that housekeeping measures should not be limited, since any nuisance factor or negative impact of landfilling operations will be a matter of public concern. Additionally, local municipal by-laws with respect to noise, dust, haulage, etc. or the general provisions of the EPA must be complied with.

It is the responsibility of site owners/operators to ensure that the site does not become a public nuisance and that a negative image of the landfill is not created within a community that is or will be benefiting from the services of a landfill.

c) Generally, spring and fall clean-ups should be carried out as a minimum at small and isolated sites. In addition, all those items listed in a) above should be controlled by a specific maintenance program.

For larger sites, and also at small sites close to sensitive land uses, housekeeping measures and their degree and frequency should be planned and included in the Design and Operations Plan for the site.

d) Compaction of waste is a beneficial yet often unrecognized means of controlling nuisance factors. Some benefits from compacting waste include reducing wind blown litter, and reducing air voids and loose waste which provide a haven for vermin, insects and other disease vectors.

e) Adherence to the established hours and days of operation can help to avoid disruptions to the neighbours and the community. For example, operation of heavy equipment and traffic flow during the evening when most people are at home may not be desirable. In some cases, modifying the hours or days of operation can assist in alleviating nuisance concerns of the neighbours and the community.

4.20.3 Housekeeping Procedures

a) Noise Control

To prevent noise travel, sound waves must be interrupted by barriers. Earth berms can often be constructed in conjunction with soil stripping at little additional cost. Topsoil, stripped from the initial disposal area, may be used to construct such berms. Topsoil from a second disposal area can provide final cover to complete the first area, and so on. The earth berms would later provide cover for the last disposal area. Care should be taken not to interrupt drainage patterns. Narrow tree belts have little effect in reducing noise levels nor noise travel.

Noise absorption or deflection can provide efficient abatement, however, the best controls deal with noise at the source. Equipment, incorporating special noise control features (e.g., muffler attachments), may be required. Well-maintained trucks and good road surfaces can prevent body rattles from vehicles. Even when off-site noise impacts are acceptable, equipment operators may need ear protection devices to prevent aural damage and permanent hearing loss. Requirements for such devices are provided in construction health and safety legislation.

b) Dust Control

Dust within and around the site can be a source of annoyance, harm and discomfort to site staff and nearby residents; it can create hazards on nearby highways. Prevention is the best control method.

Housekeeping practices to achieve dust control are as follows:

i) Soil stripping should be carried out only when soil is required for cover purposes and/or when disposal areas are required for immediate use. Permanent berms should be sodded or seeded immediately and consideration should be given to seeding soil in stockpiles; and

ii) Dust problems often occur during high winds. Appropriate fencing to deflect or dissipate the wind may assist in dust control. Light winds may spread dust stirred up by vehicle movements on unsurfaced roads.

For non-paved roads, application of dust suppressants such as calcium chloride, water, or new or re-refined oil can be beneficial. The contingency plans should ensure that water is available for spraying, but not at the expense of the water reserves required for fire fighting. Operators should note that **waste oil or used oil is not permitted** to be used for spraying.

The application of dust suppressants should take into consideration possible impacts on landfill monitoring data. For example, where calcium chloride is used, elevated levels of chloride may be indicated in the monitoring data.

c) Litter Control

Litter is a persistent operating nuisance and concern to the public. Paper and similar material scattered about the site present fire hazards and are unsightly.

Housekeeping practices to achieve litter control are as follows:

i) Picking up litter frequently is encouraged at all landfill sites;

ii) Waste unloading should be carefully supervised. Properly designed and located movable litter fencing around the unloading and spreading areas will contain most wind-blown debris, but fences must be kept clean to be effective. A clogged fence will change airflow patterns and debris will be carried over it. Earth banks or depressions, trees and other natural barriers may reduce the problems. As a general rule, waste should be deposited below rather than above the disposal faces;

iii) Site operators should encourage the general public to cover hauled loads into the landfill. Signs could be posted informing those concerned about the benefits of covering loads of waste that are trucked to the landfill. Certified waste haulers must cover their loads during transport;

iv) The application of cover material over waste is an effective means of reducing blowing litter; and

v) When adopting the trench method for disposing of waste, trenches built at right angles to prevailing winds can reduce the incidence of blowing litter.

d) Vector and Vermin Control

Landfilling sites attract vectors and vermin to feed and breed. Good waste compaction and the application of cell cover (150 millimetres of compacted earth cover material) will greatly reduce the problem by preventing the emergence of flies and by reducing the odours that attract vermin. If a problem develops, an extermination program should be conducted by a properly equipped and licensed exterminator.

e) Odour Control

Unpleasant odour is inherent in many waste types, and so elimination of all odour from waste may be difficult to achieve. Unpleasant odours should be controlled and all attempts should be made to prevent odour from reaching the boundary of the landfill site. Odour is best controlled at its source and covering waste with approved cover material as soon as it is spread is the most effective method.

f) Scavenging Birds

The most effective housekeeping practice to control scavenging birds is proper covering and compaction of waste. Other means of controlling scavenging birds such as loud noise devices, scarecrows, birds of prey and bird decoys have been tried but with limited success.

4.20.4 Inspection and Record Keeping

Regular inspection of the site to verify that nuisance factors are under control will help prevent routine operational nuisances from developing into more serious environmental problems. Site operators should maintain a check list of housekeeping items that need to be implemented regularly. Records should be kept on regular housekeeping activities carried out. These records are particularly useful for community relations purposes and for planning any changes needed to reduce nuisances.

4.21 OPEN BURNING OF WASTE

4.21.1 Rationale

The burning of municipal waste, except a limited number of specific material, is prohibited by regulation in Ontario. Open burning of waste at a landfill site creates

a) air emission concerns;
b) public and environmental hazards;
c) lack of site operational control;
d) fire hazard; and
e) nuisance.

Segregated, clean wood and brush, however, may be burned at certain isolated sites, subject to weather and atmospheric conditions and supervision requirements.

4.21.2 General Requirements

a) As part of an overall program to maximize waste capacity at existing landfill sites, thereby extending their life, open burning of clean wood and brush may be allowed under strictly controlled conditions as discussed in this subsection.

The Ministry of Natural Resources and local municipal authorities should be consulted in order to obtain any necessary permits for burning. These agencies may require specific details on safety precautions and fire prevention measures that will be taken. Landfill site owner/operators are also advised to check for any municipal by-laws enforced by the local police and fire departments. Specific regulations enforced by the Ministry of Natural Resources must be complied with for burning north of Ontario's fire line. The fire line runs east from Lake Huron across the bottom of Georgian Bay and the top of Lake Simcoe down to Gananoque, then north and west to meet the Ottawa River north of Renfrew.

b) Burning is not permitted at new landfill sites unless specifically allowed in the Certificate of Approval, usually conditional on the compliance with various environmental and safety considerations. Any permit to burn waste at new landfill sites would also be conditional on compliance with local municipal by-laws, and specific requirements of The Ministry of Natural Resources.

4.21.3 Operational Requirements

a) Weather and Atmospheric Conditions

Burning should be carried out only when prevailing weather and atmospheric conditions are suitable. Burning should not be carried out when:

i) the area has a high Air Quality Index (AQI);
ii) rain or fog are present, since smoke cannot disperse properly and may be concentrated in one particular area; and
iii) wind speeds are high or wind directions are changing frequently, because these conditions allow fires to spread rapidly.

b) Supervision

i) Dry brush and clean wood wastes should be segregated and subsequently burned on a designated, cleaned area of the site, under supervision of the site operator.

ii) The fire should be supervised continuously until completely extinguished.

iii) The site operator should clear residual ashes from a fire and dispose of the ash with normal incoming waste as soon as practically possible. The ashes must be cold prior to mixing with waste. Residual ashes should not be allowed to accumulate at the designated burning area.

c) Environmental Controls

i) Petroleum products, plastics, rubber or any other material that will cause excessive smoke or noxious fumes must not be mixed with or contaminate the wood or brush that may be burned.

ii) Burning should not be carried out if there is sensitive land-use adjacent to the landfill site or if the nearest dwelling is less than 150 metres from the site.

iii) A 30 metre fire break should be provided around the burning area.

iv) Ontario Regulation 308, made under the EPA, contains provisions dealing with air pollution. Owners and site operators are advised to apprise themselves of the provisions contained therein.

d) Extinguishing Requirements

The area of burning on the landfill site must be restricted in order to enable the operator to extinguish the fire immediately if necessary due to a change in weather or other conditions or if so ordered by MOEE or Ministry of Natural Resources staff. The operator must also provide proof of this ability (i.e., on-site equipment or written agreement with local fire control agency) to extinguish the fire.

e) Access Control

i) Access to the landfill site by the public and other unauthorized personnel must be restricted when burning is carried out.

ii) Appropriate signs should be posted at all entrances to the site used by the public and waste haulers advising them of restricted access due to burning of waste.

f) Resolution of Complaints

i) Complaints from local residents regarding smoke or odour emissions will have to be resolved by the operator. If this is not corrected satisfactorily, the operator would be required to stop burning.

ii) When persistent problems are encountered with burning at existing sites, the operator may be requested either to stop burning or make a satisfactory proposal to control burning for incorporation in the Certificate of Approval for the site. This may involve a request for amendment of a current Certificate of Approval. If the operator does not comply voluntarily with such a request, formal action to halt burning may be taken under provisions of the EPA.

4.22 FINAL COVER

4.22.1 Rationale

The closure of a landfill site requires the application of final cover to isolate the landfilled waste from surface exposure for public health and aesthetic reasons. As well, the final cover determines the infiltration of precipitation and thereby greatly influences waste decomposition rate and long term management of leachate; provides control of landfill gas; provides the appropriate ground, contours and landscape for the planned end-use of the landfill.

4.22.2 General Requirements

a) Under Regulation 347, Section 11, once a fill area has reached its final grades, final cover is required to be placed over the waste, to be regularly inspected and to be maintained.

b) Final cover should be applied progressively and generally as soon as practical, once the landfilled waste and operational cell cover have reached the approved final grades. Details of the final cover should be included in the site Design and Operations Plan. Additionally, details of the final cover including any change in design should be included in the site Closure Plan.

c) To prevent exposure of the waste from erosion, a minimum of 750 millimetres of soil final cover, including 150 millimetres of topsoil, is normally required at all landfill sites. Alternatively, a synthetic cover system with topsoil may be considered.

The design of the final cover should be consistent with the overall leachate control design in complying with the MOEE Reasonable Use criteria and able to adequately support the planned end use of the site. For these reasons, depth of final cover greater than the minimum specified above may be necessary. It is important to note that the final cover must function as long as necessary for the protection of the environment. Evidence must be provided by the landfill owner that this can be accomplished through adequate design, maintenance and repair.

4.22.3 Leachate and Gas Management

The infiltration of rain, snowmelt, or other surface water through the final cover of the landfill has the greatest effect on the volume and rate of leachate generation. The presence of moisture promotes the decomposition of the waste and stabilization of the landfill.

Final cover is generally not intended to prevent rain or surface water infiltration, but to control infiltration so that leachate generation and waste decomposition and the resulting formation of gas can all proceed at a controlled manner.

High permeability design of the final cover promotes greater infiltration of water into the landfill, and is believed to result in accelerated biodegradation of the waste, reduction of the time period during which settlement is most rapid and the landfill produces its most contaminating leachate. Inherent to such a design is relatively high volume and rate of leachate generation. Where, natural attenuation is not expected to be adequate at the site, leachate collection and treatment is necessary. As leachate treatment is generally very costly, the economics of long term management of possibly high volume of leachate should be considered at the initial design stage of the landfill.

The low permeability design of the final cover is intended to significantly decrease the infiltration in order to reduce the volume and rate of leachate generation. This reduction of infiltration generally retards the decomposition process and extends the contaminating lifespan of a landfill. Surface run-off of water and high evapotranspiration are generally promoted. However, where water tightness is achieved, the landfill essentially behaves as a "dry" underground storage site for waste.

The design of the final cover should be consistent with the overall design of the landfill. It is one component of the landfill control facilities to ensure that the site can comply with MOEE Reasonable Use criteria and manageable volume of leachate is generated, collected and treated or hauled off-site.

Lower permeability design final cover results in the greater surface run-off of rain water or snowmelt. The surface drainage must be considered in the final cover design to avoid erosion problems and protect adjacent properties and nearby water courses.

The final cover can be designed to permit upward venting of the landfill gas, a by-product of waste decomposition. Any impediment, by design, of this upward venting will increase the lateral migration of the landfill gas. The concerns for the landfill gas should be addressed.

4.22.4 Support of End Use

The final cover should be designed to support the after closure land use of the site. Typical end uses include parkland or open fields; other possibilities may include animal pasture, forest production, conservation area, commercial and industrial development or even agricultural use. For example, the end use as parkland or open field may require vegetation and soil depth, conditions and moisture retention to sustain the vegetation with after closure maintenance. Landfill concerns such as leachate, landfill gas and uneven settling of land should be carefully considered in the design of the final cover in supporting the end use. It should be noted that approval under Section 46 of the EPA is required for the establishment of the end use.

4.22.5 Soil Covers

a) A simple final cover consist of soil layer of specified permeability covered with topsoil capable of supporting vegetation.

b) In more complex cases, composite final cover may be necessary and could consist of several layers including:

i) subgrade layer of suitable soil used to smooth out rough spots and fill depressions,
ii) layer of coarse, high permeability sand and gravel used to capture and vent migrating gases,
iii) filter layer to minimize movement of fine soils downward into the gas collection layer,
iv) soil of appropriate permeability to control infiltration, and
v) topsoil layer.

The surface slope of 20:1 horizontal to vertical (or 5%) to 4:1 (or 25%) is typically recommended. Higher the slope, greater the surface run-off, possibly resulting in greater erosion of cover material and loss of vegetation. As well, possible slope failure and surface safety of personnel and vehicle travel will be of concern at higher slopes. At lower slopes, there will be less surface run-off, and depending upon the permeability of the final cover, this can result in ponding or greater infiltration of water into the landfill.

Where low permeability is the intended design, the successive layers, with the exception of the topsoil, should be well compacted and surface run-off of water and high evapotranspiration promoted. Simple and complex soil cover systems with low permeability design are illustrated by Figures 4.22 (A) and (B).

4.22.6 Synthetic Covers

Synthetic covers, or geomembranes, can be used in place of soil, particularly where adequate quantities or suitable soils are not readily or economically available. Typically, synthetic membrane covers are used to prevent infiltration of water into the landfill.

Usually, it is necessary to place a subgrade layer of fine to medium aggregate to smooth out the landfill surface and to fill depressions before the synthetic material is placed. Depending on the slope of the final land form, a geotextile may be required between the subgrade layer and the synthetic membrane to prevent slipping. An additional protective layer of soil will usually be placed immediately above the membrane to protect it from wind uplift and

deterioration by weather or damage by heavy equipment. The top surface is typically graded to promote run-off. Topsoil is placed and vegetation established.

The synthetic membrane will generally impede the upward venting of the landfill gas. Typically, some method of gas venting is required to prevent gas build-up within the landfill, which would promote lateral gas migration.

When synthetic membranes are to be employed, consideration should be given to the likely effects of uneven landfill settlement and the associated long-term maintenance and repair that may be required as a result. Also, the design life of the synthetic cover system in relation to the contaminating life of the landfill may necessitate the replacement(s) of the synthetic cover.

4.22.7 Vegetation

The reasons for establishing vegetation on the final cover of the landfill include the prevention soil erosion, promotion of evapotranspiration or enhancement of the appearance of the site.

When selecting vegetative cover for a landfill, soil factors such as texture, pH and nutrient content should be considered. Generally, pH ranges from 5 to 8 are suitable for plant growth. Major nutrients such as phosphorous, nitrogen and potassium are needed in appropriate quantities to promote and sustain growth. The most suitable vegetation to be employed in a particular area could be determined with the assistance of local transportation and road authorities, agricultural and soil conservation representatives or other agriculturists.

In most cases, the vegetation should be shallow rooted, gas resistant and hardy. The evapotranspiration potential of the vegetation should be in accordance to the overall design of the landfill. Seed mixes containing both annual species that quickly establish cover and perennial species that are established over the long-term, are recommended. Vegetation that has been successfully employed at landfills includes brome grass, Kentucky bluegrass, timothy, and crownvetch.

Seeding should be undertaken immediately following final grading. If hydroseeding is employed, organic mulches such as straw, wood chips or manure could be added to the seed mix to protect the seeds from erosion prior to germination, to maintain soil moisture and to inhibit weed growth. On steep slopes, hay and straw mulches also serve to reinforce the soil structure after the cover has been established.

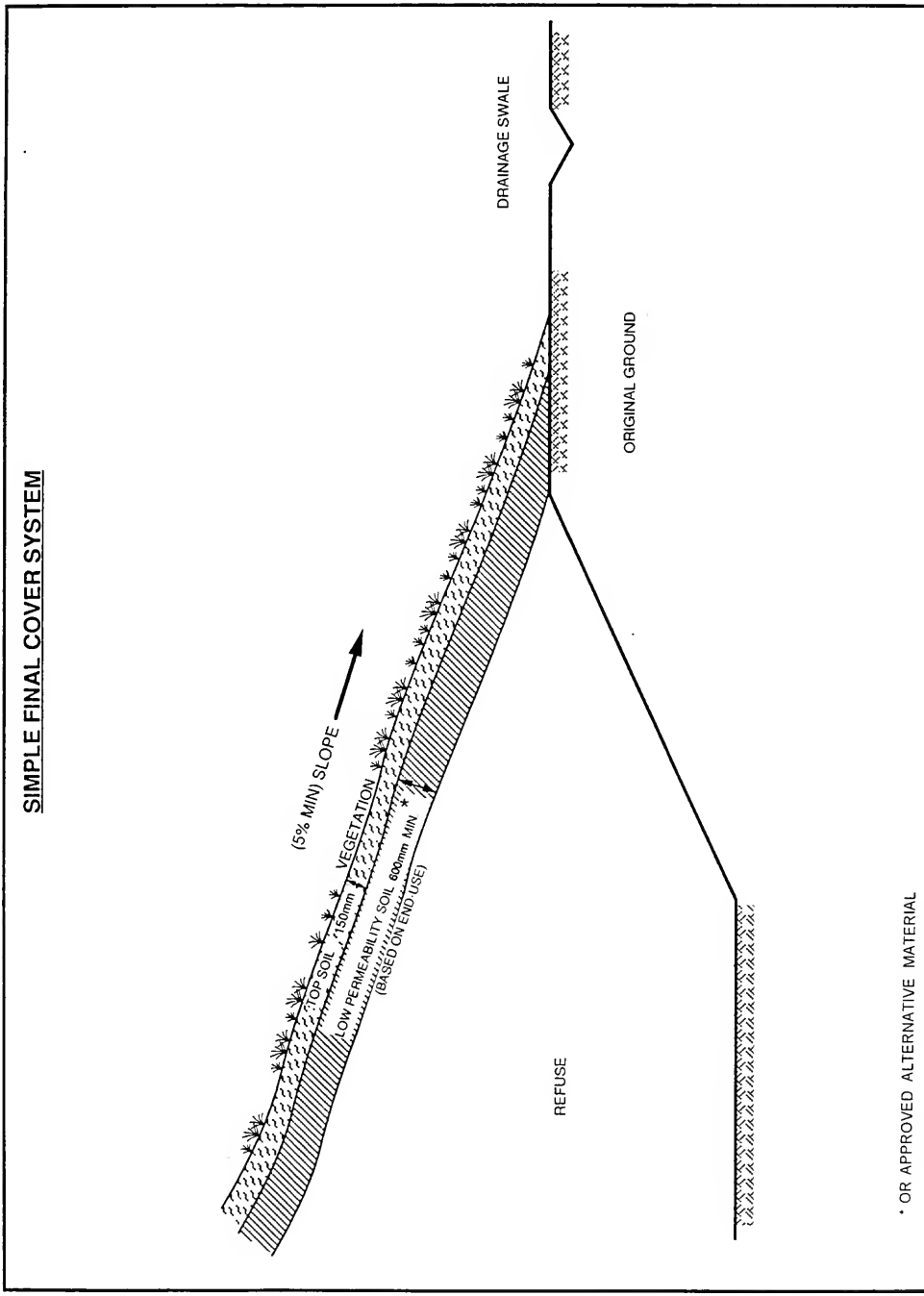

SIMPLE FINAL COVER SYSTEM
(5% MIN) SLOPE
VEGETATION
TOP SOIL 150mm
LOW PERMEABILITY SOIL 600mm MIN
(BASED ON END USE)
DRAINAGE SWALE
ORIGINAL GROUND
REFUSE
* OR APPROVED ALTERNATIVE MATERIAL

FIGURE 4.22 (A)

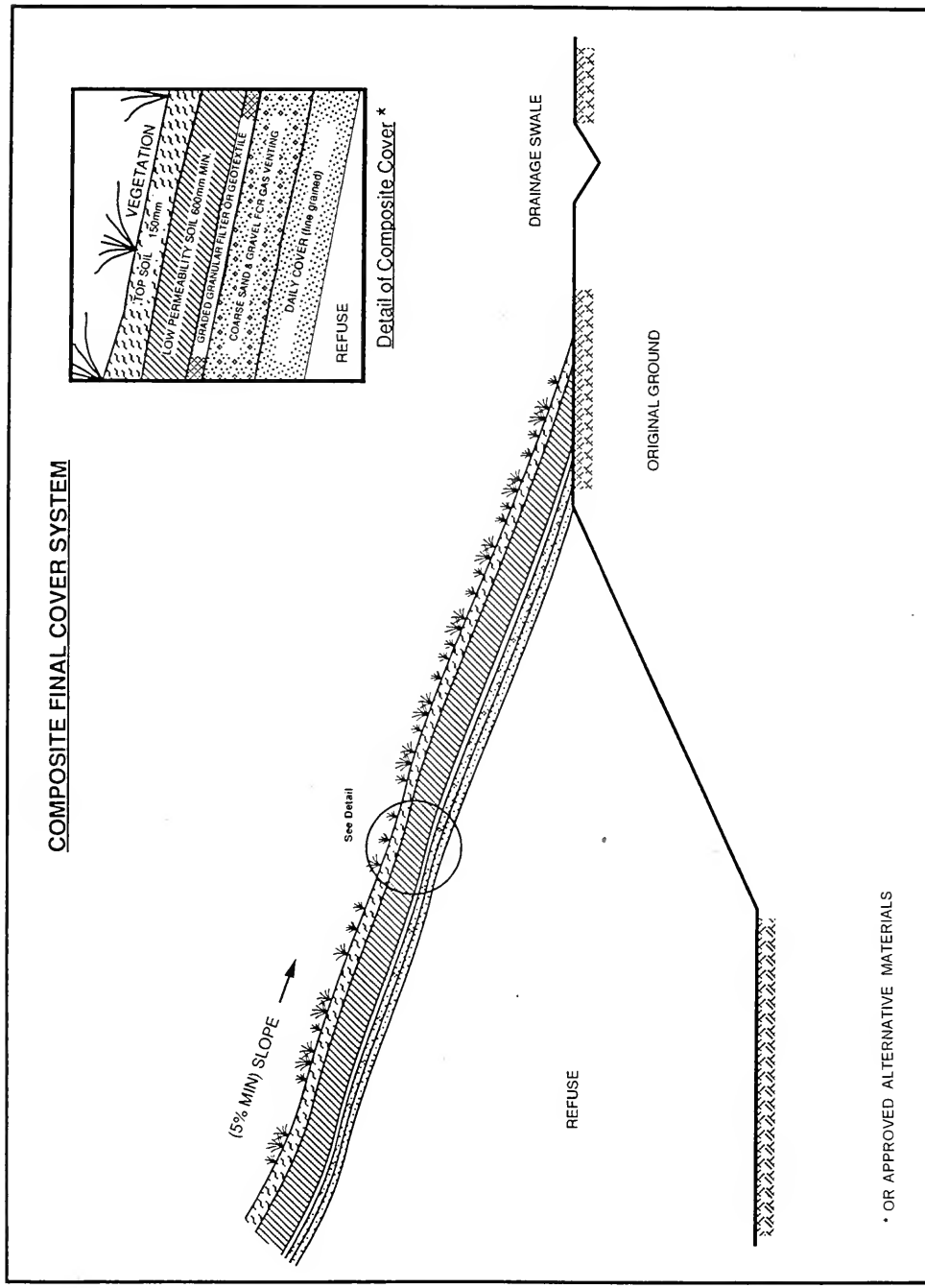

COMPOSITE FINAL COVER SYSTEM
VEGETATION
TOP SOIL 150mm
LOW PERMEABILITY SOIL 600mm MIN
GRADED GRANULAR FILTER OR GEOTEXTILE
COARSE SAND & GRAVEL FOR GAS VENTING
DAILY COVER (fine grained)
REFUSE
Detail of Composite Cover *
DRAINAGE SWALE
ORIGINAL GROUND
See Detail
(5% MIN) SLOPE
REFUSE
* OR APPROVED ALTERNATIVE MATERIALS

FIGURE 4.22 (B)

4.23 MONITORING PROGRAM

4.23.1 Rationale

The goal of monitoring is to verify the adequacy of the site design and operations in having an acceptable impact on the environment and the community as predicted during the initial site design phase. Routine monitoring allows the determination of contaminant egress from the landfill, if any, and alerts the site owner/operator to environmental problems. Potential problems of the future may be recognized from the analysis of the trends of the monitoring data collected over the years. The early warning of developing problems will allow for corrective measures to be taken thus avoiding or lessening any potential environmental damage. Corrective actions may mean modifications to the site design or operations, or the implementation of the Contingency Plan.

A monitoring program also serves the purpose of providing the general public directly or through regulatory authorities such as the MOEE, with information on the performance of the landfill and the protection it affords to the environment as a result of sound planning, design and operations. This information will be invaluable in assessing the effectiveness of on-site controls and buffering capability.

4.23.2 General Requirements

a) Regulation 347, Section 11 requires landfill owners to take samples and test them in order to measure the extent of egress of landfill contaminants.

b) The components of the monitoring program can include monitoring of the ground water, surface water, leachate, liner performance and gas migration. The inspection (or monitoring) of landfill site operations are discussed in Subsections 4.18 Supervision and 4.20 Housekeeping.

The design of the water monitoring program requires a hydrogeologic investigation. The hydrogeological investigation, discussed in Subsection 3.5, will define the geology and hydrology of the site and will relate these factors to the hydrogeologic system both locally and regionally. The investigation will also define the stratigraphic unit(s) susceptible to contamination by the landfill and provide an understanding of ground water and surface water flow in the vicinity of the site enabling the prediction of the immediate and long-term impact of the site on the environment. The hydrogeologic investigation should establish a monitoring network which is capable of detecting contaminant egress from the site and recommend an environmental monitoring plan. The environmental monitoring plan is based on hydrogeologic factors, including attenuation and dilution characteristics, ground water quantity and quality, flow rates,

flow paths, and anticipated rates and directions of contaminant movement. The plan should, as a minimum, contain the following:

i) the number, locations, sizes and depths of wells, lysimeters, borings, pits, piezometers and other assessment structures and devices to be used, as well as, the number and location of surface water monitoring stations;
ii) the water quality parameters to be measured;
iii) the sampling and analytical methods/procedures that ensures representative samples and consistent, accurate analysis of the parameters;
iv) the evaluation procedures to determine the concentration, rate and extent of ground water degradation or pollution from the facility; and
v) an implementation schedule.

c) The MOEE has detailed it's policies and procedures for monitoring at landfill sites in the following documents:

- "Advice to Applicants and to Consultants in Preparing Hydrogeologic Reports for Proposed Landfills";
- "The Incorporation of the Reasonable Use Concept into the Ground Water Management Activities of the Ministry of the Environment";
- "Land Use on or Near Landfills and Dumps"; and
- "Guideline for Assessing Methane Hazards from Landfill Sites".

4.23.3 Scope of the Monitoring Program

a) Operational Monitoring Program

The scope (frequency, parameters measured, number of sampling points, etc.) of the required monitoring program is site-specific. It should be discussed with MOEE Regional staff who are familiar with monitoring requirements at other similar sites. A number of factors should be considered in the planning and implementation of the environmental monitoring program:

i) site location;
ii) site size and size of buffer area;
iii) geologic complexity and ground water conditions (depth to the water table, site proximity to local and regional aquifers, ground water flow rates and paths, degree of natural protection to aquifers, etc.);
iv) on-site and near-by surface watercourses or lakes;

v) local land and water uses and the potential of the landfill operations to impair local water supply wells and surface water;
vi) proximity of the site to sensitive land uses;
vii) leachate management - engineered (lined with natural or synthetic barriers), a naturally attenuated site, or a combination;
viii) pre-landfill, operational or post-closure period;
ix) evidence of environmental degradation from the landfill; and
x) performance of the landfill to date.

b) Baseline Monitoring Program

Prior to the opening of a new landfill it is recommended that monitoring data from at least two sampling events be collected to establish pre-landfill water quality and the ground water flow system. Ideally, data establishing seasonal variations over the course of a number of years are desirable to demonstrate baseline conditions and any effects of seasonal activities such as, road salting, dust suppressant application, and fertilizer or pesticide use.

It is advisable for the baseline monitoring program to be a comprehensive one as future data will be measured against the pre-landfill conditions.

d) Post-Closure Monitoring Program

The scope of the post-closure monitoring program is site-specific and similar to that of the operational monitoring program. Some degree of post-closure monitoring will be required for landfill sites currently in operation.

4.23.4 Components of the Monitoring Program

The components of the monitoring program can include monitoring of the ground water, surface water, leachate, liner performance and gas migration.

a) Ground Water Monitoring

The most common type of monitoring device is a well point where a screened, or perforated pipe is installed in a sealed protective casing. Specific features are selected according to site-specific needs. In complex hydrogeologic situations, many such well points may be necessary. Tiles, lysimeters, surface water bodies, springs, or nearby water wells may also be used for monitoring purposes.

Instruments, such as piezometers and standpipes are strategically located within and around the site. Their actual arrangement will be governed by the type, composition and sequence of

underlying and adjacent soils or geologic materials and the predicted flow paths of various types of contaminants.

The hydraulic conductivity of the geologic materials and the types of openings (e.g., geological faults, fractures, joint sets and intergranular pores) through which the ground water moves, the water table depth and the hydraulic gradient are each of particular importance in relation to contaminant pathways and velocities. The locations of recharge and discharge zones are also important consideration. In accordance with sound engineering principles, substantial factors of safety should be provided in the design and operation of monitoring systems.

i) On-site Monitoring Network

The monitoring network should be specifically designed to adequately assess the impact of the landfilling operations on ground water at each site.

- Location and number of wells

  At least one well should provide representative data of ground water not affected by the landfill in each aquifer that is monitored. It may be located hydraulically upgradient of the site, beyond the edge of the contaminant plume.

  At least one monitoring well (standpipe) should be located in the landfill area to provide information on leachate quality.

  Down-gradient wells should be sufficient in number and installed at locations and depths to provide water quality data that will be representative of ground water quality down-gradient of the landfilling operation. They should be situated so they will provide early detection of ground water degradation originating at the disposal area. They should be placed where they will not interfere with landfill operations. A simplified monitoring network is shown in plan view and cross-section in Figures 4.23 (A) and 4.23 (B) respectively.

- Nesting of wells

  Where the geologic stratigraphy is complex, monitoring of all potentially affected aquifers and aquitards is required. In such a situation, wells should be installed in nests, where ground water zones at various elevations are monitored at the same location. Typical well nest construction is shown on Figure 4.23 (C).

- Drilling and Construction

  Drilling for the installation of monitoring wells should be conducted by a licensed well contractor. All monitoring wells and piezometers should be designed and constructed to prevent contaminant transport up or down the well bore between aquifers. Well construction must comply with the Ontario Regulation 903 Wells. During all phases of well construction, drilling, installation and completion, the methods and materials used should not introduce substances that will interfere with water quality analyses. Specifically, this includes the following:

  - the use of drilling fluids, mud, foams, dispersants, disinfectants, other additives and water from outside the well should be minimized and used only if necessary. If used, methods used to remove these materials from the well should be identified;
  - drilling tools, cables and well materials should be clean and free of greases, oil and other contaminants;
  - equipment that comes into contact with contaminated soil or ground water should be thoroughly cleaned before drilling to greater depths or in other drilling locations; and
  - zones which are contaminated should be cased off before drilling deeper.

- Well Materials

  Materials used in well casings, screens and seals should be resistant to chemical attack, corrosion and other deterioration. In particular, the well components should be compatible with the contaminants or chemicals that are expected to be encountered. Casings and screens should also be pre-threaded and gasket sealed to preclude the use of glues and solvent welded joints. The screens and casings must be centred in the hole to ensure a continuous seal around the casing. Granular filter packs placed around the screen should consist of an insoluble, non-reactive material that is sized, graded and washed for this purpose. Silica sand is recommended.

- Well Design, Installation and Development

  Monitoring wells should be designed and constructed to function properly over the intended operational life of the well, to prevent vertical movement of ground water and contaminants within the well and the drill hole and to be pressure tight without leakage at casing joints.

Each well within the monitoring network should be designed based on the site hydrogeologic characteristics. Screen lengths should be chosen to monitor discrete zones of contaminant migration.

Typical monitoring well construction for standpipes and piezometers is detailed in Figure 4.23 (D).

Each monitoring well should be developed (i.e., pumped) to minimize, after installation, the entry of sediments into the well and to ensure removal of foreign substances introduced during drilling and well installation.

- Protection of wells

Monitoring wells should be protected against damage from equipment and vandalism and unauthorized access should be prevented. A protective casing, cemented in place and equipped with a locking cap, should be installed at each well. The protective casing should be painted in a highly visible colour. The well location should be marked so that it is visible during winter snow conditions.

- Labelling

Each well should be clearly and permanently identified.

ii) Off-site Monitoring Network

Sampling and analysis of ground water and/or surface water beyond the site boundaries may be required to determine the nature and extent of contamination. Local domestic wells may need to be included as part of the routine monitoring around the landfill site, depending on their proximity and the local hydrogeologic conditions. This can provide assurance that private wells are not contaminated by the landfill.

iii) Ground Water Sampling and Analysis

The procedures and techniques for ground water sample collection, preservation and analysis should be in accordance with standard practices of the scientific community. For example, stagnant water should be removed from the well before sampling. The type of sampling device and containers used should be indicated. Records should be kept of the chain of custody and field, and laboratory quality assurance/quality control procedures.

Sampling frequency is site-specific based on the anticipated rates of movement of the contaminants and is adjusted according to the actual observed rates. Ground water

velocities are usually much lower than those of surface waters. Therefore, for ground water, the intervals between sampling are relatively long.

The water quality parameters that should be measured are site-specific. The list may be based on historical water quality data, but should contain, at a minimum, contaminants that are commonly found in landfill leachate. Sometimes, conservative indicator parameters, such as chlorides, are monitored to provide an early warning system for the movement of contaminants. Method detection limits for the measured parameters should be at levels that provide meaningful data for the comparison with historical concentrations and water quality standards (i.e., Ontario Drinking Water Objectives).

In selecting specific test parameters to determine leachate components, the types of wastes being disposed of should be considered. The waste groups generically identified can include domestic refuse; sewage sludge; ash; and non-hazardous solid commercial and industrial wastes. For example, higher levels of nitrate may be typically found in sewage sludge as compared to domestic refuse. A set of key indicator parameters, typical of one of the above waste groups, will be included in the monitoring program depending on the relative quantities of the waste groups landfilled at the site.

iv) Ground Water Level Measurements

Ideally, water levels should be referenced to mean sea level, but may be reported relative to a site datum. At monitoring wells used to collect water level data and sample water quality, the water level should be measured prior to any disturbance due to sampling.

b) Surface Water Monitoring

i) Monitoring Network

Surface water quality should be measured to assess leachate control and containment facilities, run-off control and the impact of contaminated ground water discharge to watercourses. Measurements at a location upstream of the landfill are recommended for comparative purposes. The number of downstream sampling stations will be determined by the sensitivity of watercourses in surrounding areas, the size of the landfill and other requirements dictated by the hydrogeology and hydrology at the site. Permanent markers are recommended to identify the monitoring stations.

ii) Surface Water Sampling and Analysis

The rationale for the selection of surface water quality parameters that is required for analysis, and the relevant water quality standards that they are compared to, are similar

to the discussions in the preceding sub-section **a)**,iii) Ground Water Sampling and Analysis.

iii) Stream Flow Measurements

In special cases, surface water quantity monitoring may be required, as the landfill may restrict infiltration and decrease base flow in nearby streams (especially at lined and large landfill sites). Both upstream and downstream monitoring locations may be required. Many types of stream flow gauges and gauging structures are available for this purpose.

c) Leachate Monitoring

Leachate quality analysis should be included in the monitoring program both for sites which collect and dispose of leachate and for those where leachate is naturally attenuated by the environment. At sites where leachate is collected, and either treated or disposed of at an appropriate off-site facility, records of leachate volumes should be routinely kept.

Parameters that are typically monitored in a landfill leachate monitoring program may include the following:

- alkalinity (CaCO3),
- BOD (5 days),
- calcium,
- chloride,
- COD (Chemical Oxygen Demand),
- conductivity,
- copper,
- DOC (Dissolved Organic Carbon),
- hardness ($CaCO_3$),
- lead,
- magnesium,
- nitrate,
- nitrogen - ammonia (NH_3),
- nitrogen - Kjeldahl,
- selected organics,
- phenols,
- pH,
- potassium,
- sodium,
- sulphate,
- total iron,
- total phosphates,

- total suspended solids, and
- zinc.

d) Liner Performance Monitoring

In cases where a landfill site is lined, liner performance monitoring becomes one of the most important aspects of the monitoring program. At lined sites, the liner is the protection to the environment from landfill contamination and failure of the liner to perform as specified may be very damaging. Monitoring wells should be located as close as is practicable to the lined area to provide the earliest indication of liner leakage or major liner failure. Provision for the installation of ground water monitors beneath the liner should be made prior to the liner placement.

Changes in the ground water flow system at a lined site may occur due to reduced recharge as a result of liner installation. Ground water flow direction changes may necessitate modifications to the ground water monitoring network. Additionally, decreased recharge may adversely affect the base flow in nearby streams.

e) Gas Migration Monitoring

Active landfills must have methane gas controlled on the site. As a general rule, methane gas may migrate for a distance of ten (10) times the depth of the landfill between the ground surface and the water table. Monitoring may be required as part of the routine environmental program to assess any hazard that methane gas poses, particularly where there may not be sufficient buffer area to allow for natural attenuation of the gas or where no natural barriers to migration exist (saturated conditions too near ground surface or a ravine or valley that is at a lower elevation than the base of the fill).

Gas probes should be designed to take site-specific conditions into consideration. They should be installed above the water table. Where the unsaturated layer adjacent to deep landfills is thick, gas probes, installed to monitor at discrete intervals, are recommended. Monitoring of the probes when the ground is frozen will reveal conditions where the extent of gas migration may be maximum.

Additional information on landfill gas control is provided in Subsection 4.11. As well, they are advised to refer to the MOEE "Guideline for Assessing Methane Hazards from Landfill Sites" and its accompanying "Appendix A". A typical gas monitoring probe is illustrated in Figure 4.11 (A).

4.23.5 Data Analysis

As discussed in Subsection 3.6, analysis of the collected data from monitoring is essential in measuring the performance of the landfill design and may predict continued performance of the site to acceptable levels.

a) Water Quality Data

Water quality data from ground water and surface water stations should be tabulated by date with all historical data included. Trends over time in the concentrations of key landfill contaminant indicator parameters (typically BOD, phenolic compounds, chlorides, etc.) should be examined. For this purpose, graphical representation is most useful. Generally, the following comparisons should be considered:

i) The monitored data, from each monitoring locations, should be compared (for compliance) to relevant water quality standards/criteria, including, but not limited to, MOEE Reasonable Use criteria, Ontario Drinking Water Objectives, Provincial Water Quality Objectives, "trigger" levels for implementation of contingency plan;

ii) The monitored data collected from different locations should be compared. For example, down-gradient wells with upgradient ground water quality, down-gradient surface water with upgradient surface water quality; and

iii) The change in contaminant concentration over time, for each monitoring locations, should be determined. The water quality data from the current monitoring period should be compared to baseline concentrations, past monitoring data and predicted values. The current data should also assist in updating the prediction of future monitoring values.

b) Ground Water Flow

Water level measurements should be tabulated by date with historical data included. Graphs of water level versus time at each well are useful to determine changes in water levels induced by the landfill operation.

A ground water flow map should be constructed to show flow direction at the site and in the immediate vicinity to aid in determining the direction of landfill-derived contaminant migration.

Hydraulic gradients (both lateral and vertical) should be calculated. These should be used to calculate ground water flow velocities and combined with information on variations in permeability, to estimate rates of contaminant migration at the site.

c) Gas Migration

Combustible gas concentrations found in soils should be tabulated by date and plotted on a site map. Contouring of gas concentrations is recommended to easily identify the extent of gas migration.

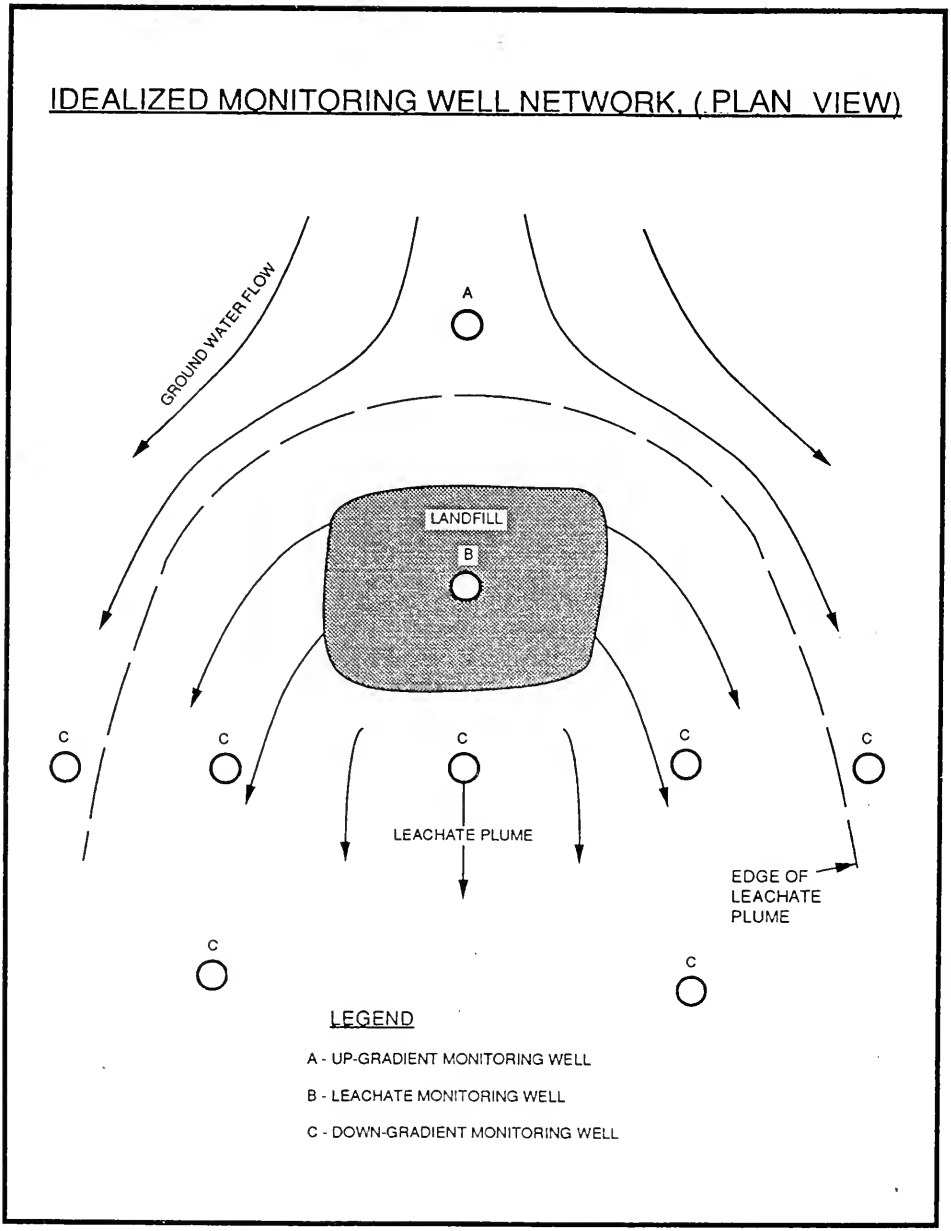

IDEALIZED MONITORING WELL NETWORK, (PLAN VIEW)
GROUND WATER FLOW
A
LANDFILL
B
C
C
C
C
C
LEACHATE PLUME
EDGE OF
LEACHATE
PLUME
C
C
LEGEND
A - UP-GRADIENT MONITORING WELL
B - LEACHATE MONITORING WELL
C - DOWN-GRADIENT MONITORING WELL

FIGURE 4.23 (A)

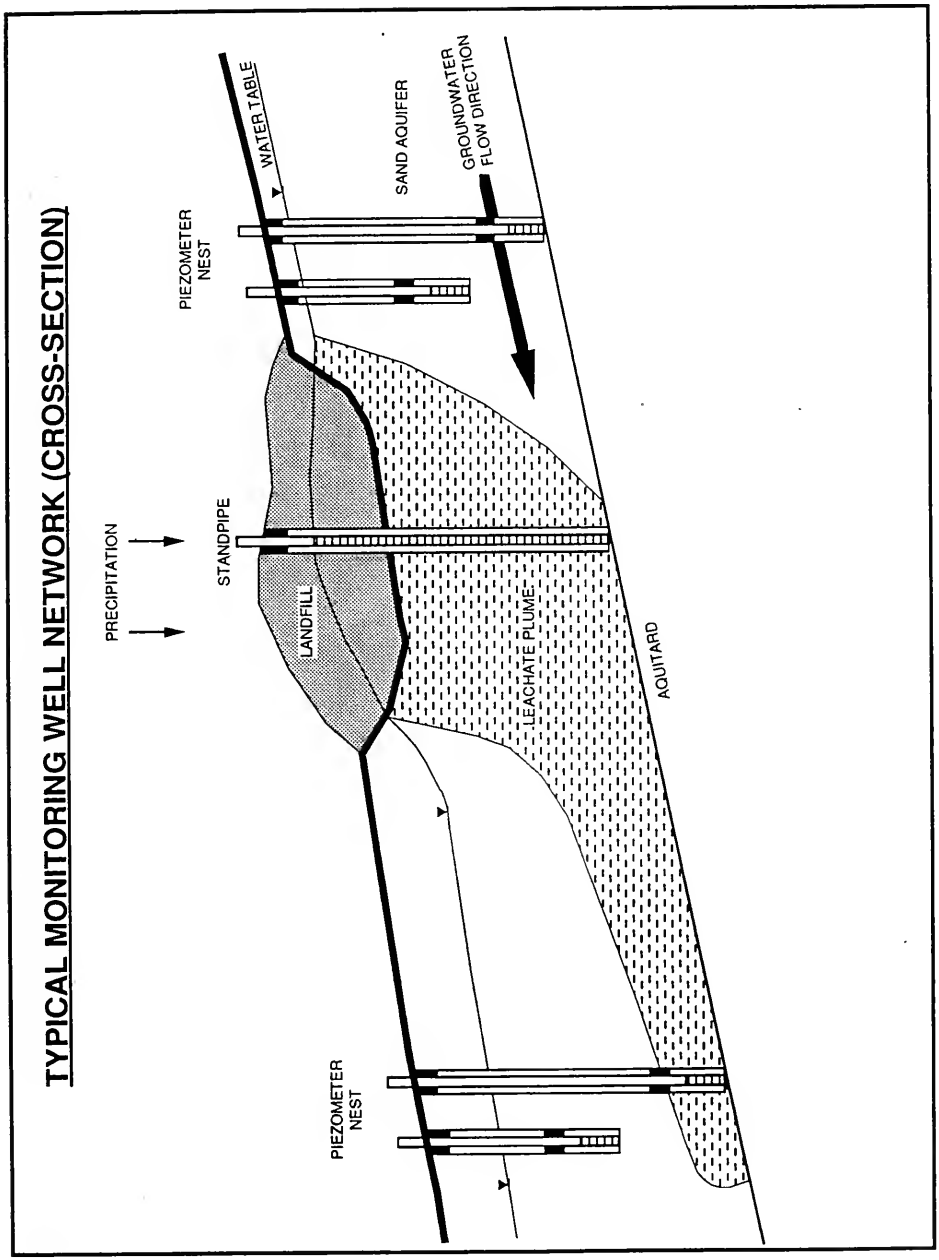

TYPICAL MONITORING WELL NETWORK (CROSS-SECTION)
PRECIPITATION
PIEZOMETER NEST
STANDPIPE
WATER TABLE
SAND AQUIFER
GROUNDWATER FLOW DIRECTION
LANDFILL
LEACHATE PLUME
AQUITARD
PIEZOMETER NEST

FIGURE 4.23 (B)

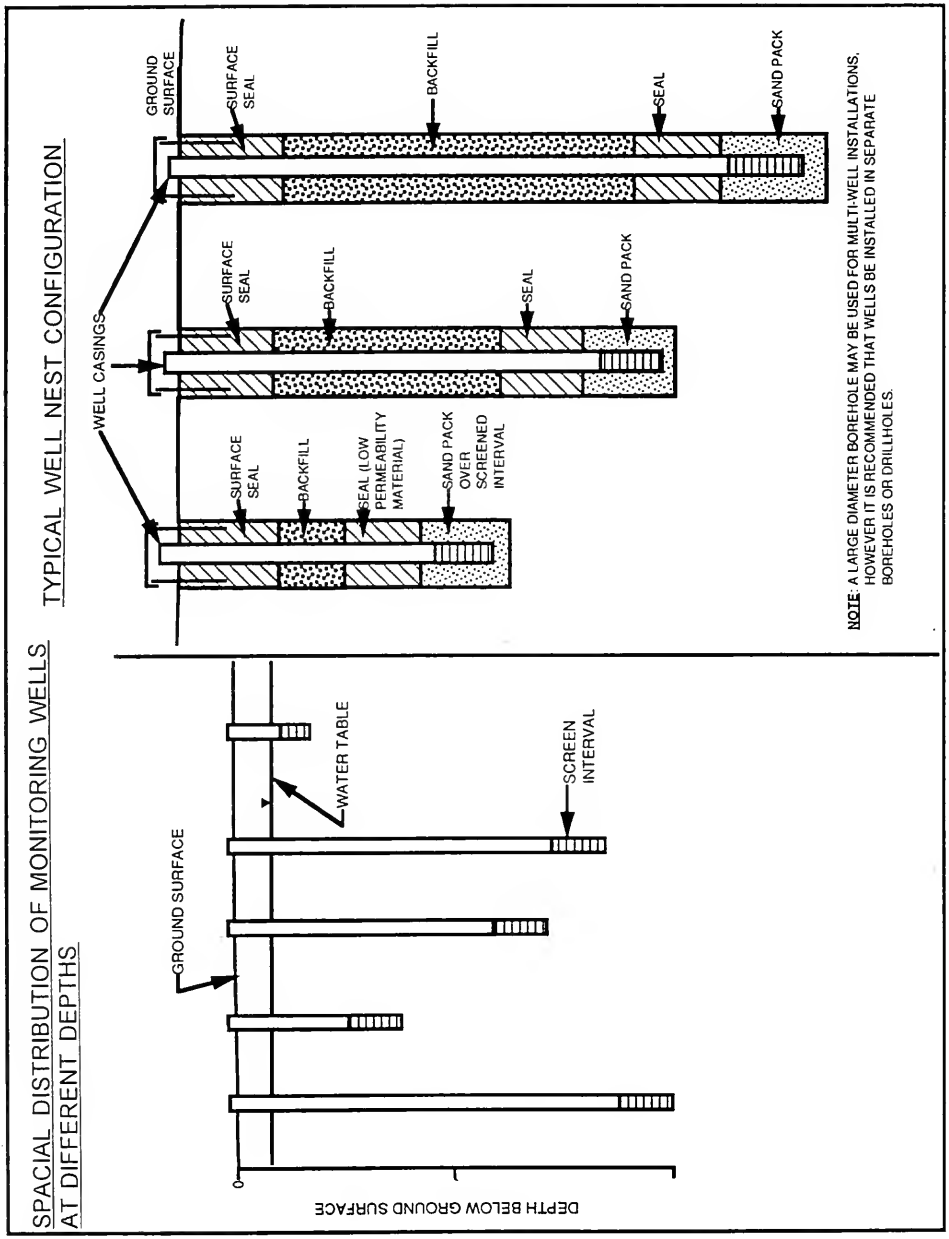

SPACIAL DISTRIBUTION OF MONITORING WELLS AT DIFFERENT DEPTHS
GROUND SURFACE
WATER TABLE
SCREEN INTERVAL
0
DEPTH BELOW GROUND SURFACE
TYPICAL WELL NEST CONFIGURATION
WELL CASINGS
GROUND SURFACE
SURFACE SEAL
BACKFILL
SEAL
SAND PACK
SURFACE SEAL
BACKFILL
SEAL
SAND PACK
SURFACE SEAL
BACKFILL
SEAL (LOW PERMEABILITY MATERIAL)
SAND PACK OVER SCREENED INTERVAL
NOTE: A LARGE DIAMETER BOREHOLE MAY BE USED FOR MULTI-WELL INSTALLATIONS. HOWEVER IT IS RECOMMENDED THAT WELLS BE INSTALLED IN SEPARATE BOREHOLES OR DRILLHOLES.

FIGURE 4.23 (C)

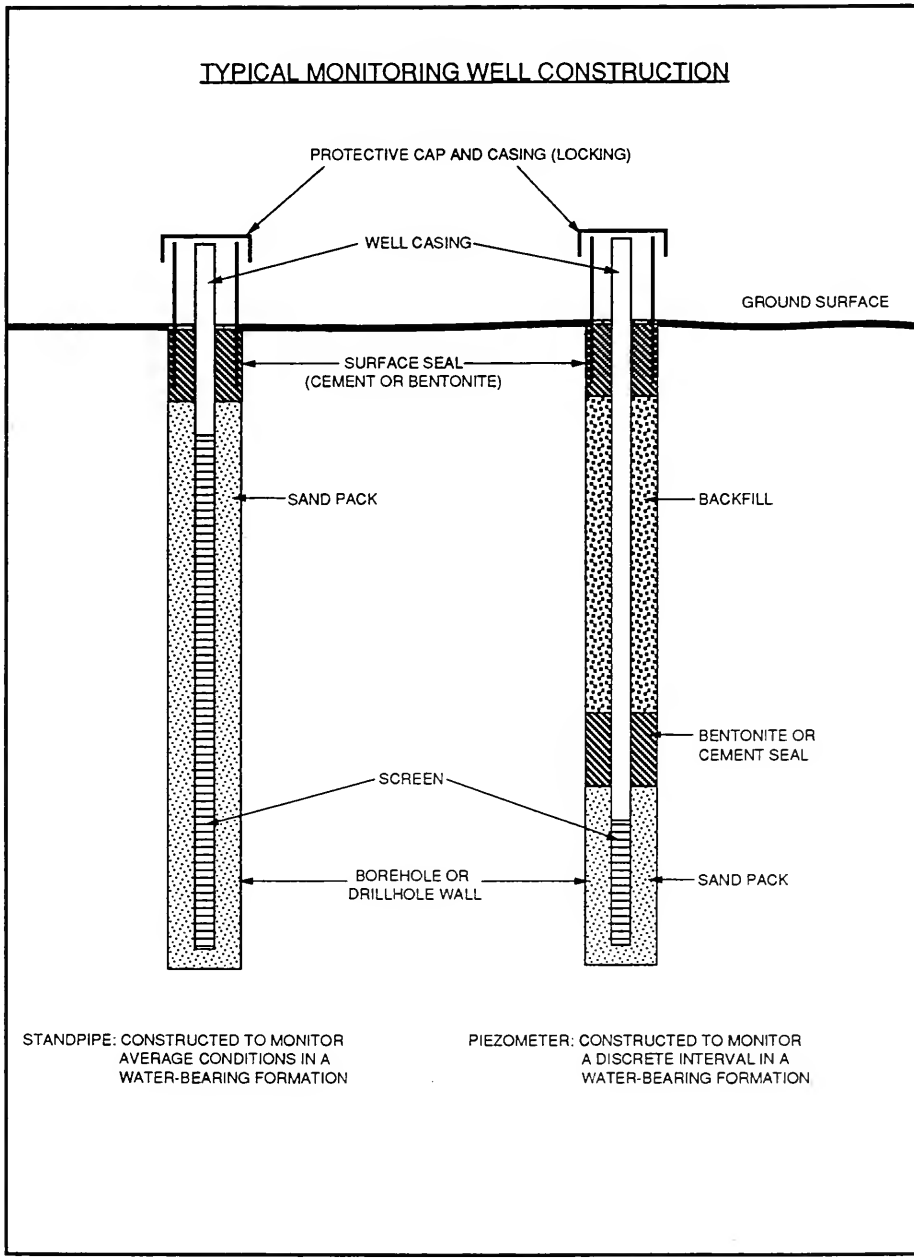

TYPICAL MONITORING WELL CONSTRUCTION
PROTECTIVE CAP AND CASING (LOCKING)
WELL CASING
GROUND SURFACE
SURFACE SEAL
(CEMENT OR BENTONITE)
SAND PACK
BACKFILL
BENTONITE OR
CEMENT SEAL
SCREEN
BOREHOLE OR
DRILLHOLE WALL
SAND PACK
STANDPIPE: CONSTRUCTED TO MONITOR
AVERAGE CONDITIONS IN A
WATER-BEARING FORMATION
PIEZOMETER: CONSTRUCTED TO MONITOR
A DISCRETE INTERVAL IN A
WATER-BEARING FORMATION

FIGURE 4.23 (D)

4.24 STATUS REPORTS

4.24.1 Rationale

The Status Reports provide the progress status of the landfill operations and performance by the owner and operator to the MOEE. These Reports provide information on the actual site conditions in comparison of the predicted site conditions which had determined the design criteria of the landfill. It also provides information on the adequacy of the constructed facilities for the life of the landfill.

4.24.2 General Requirements

Status Reports should include items such as operating information, e.g., any variance from the development plans; complaints received regarding the operation of the site, if any; monitoring data and their interpretation; and any anticipated changes in the operation and the management of the site.

The analysis and interpretation of the monitoring data and other observations are normally required in the Status Report. The identification of problems and possible problems in the operation and management of the landfill is the responsibility of the landfill owner and operator. This is the first step in the implementation of any remedial or contingency measures.

Status Reports normally cover a one year period. Under circumstances where unacceptable levels of contamination have been measured, more frequent reporting may be required by the MOEE.

4.24.3 Contents of Status Reports

The following items are recommended for inclusion, however, the content and level of detail in the Status Reports will vary depending on the size, operations and complexity of each landfill site.

a) Executive Summary

Brief summary of the Report and conclusions and recommendations

b) General

i) Site location map (regional).

ii) A brief site history, licensed site size and Certificate of Approval number.

iii) Site map showing; property boundaries, approved fill area, buffer area, locations of access roads, facility office, erosion and sedimentation controls, leachate storage and treatment facilities, on-site monitoring wells, surface water monitoring stations, monitored domestic wells, gas probe locations, etc.

c) Environmental Quality Monitoring

i) Well details; depth, screen length and elevation, filter pack location, seal location, elevation of the top of the casing, ground elevation, construction materials, diameter of screen and casing.

ii) Methods and frequencies of sample collection and sample analysis.

iii) Water level measurements, indicating the date of measurement, tabulated with historical data. Graphical presentation of water levels over time is useful.

iv) Ground water and surface water flow direction map for the site and immediate area.

v) Chemical analyses with comparison to historical and background data and interpretation of the degradation of local ground water quality relative to background. Graphical presentation of water quality data over time is useful for discerning recent and long-term concentration trends. Charge balance errors for chemical analyses should be provided and discrepancies explained.

vi) A map showing the areal extent of any ground water degradation (delineation of the contaminant plume).

vii) Calculations, showing the sources of data and equations used for hydraulic gradients, flow velocities, water balance and the rate and direction of contaminant migration.

viii) Results of gas monitoring, reported as a percentage by volume of gas. Contouring of gas concentrations found around the fill is desirable.

ix) Summary of liner performance.

x) Comparison of data to the Reasonable Use Policy, the trigger for implementing the contingency plan, Ontario Drinking Water Objectives and other pertinent policies and standards.

d) Site Operations

i) The total amount and types of waste (percentages of the total) accepted during the monitoring period.

ii) Information (location, dimensions, depth and construction data) pertaining to the construction of any berms, dykes, trenches, liners, drainage facilities, sedimentation ponds and gas venting structures associated with the landfill.

iii) The extent of filled area.

iv) The extent of area that has received final cover.

v) The extent of completed areas with established vegetation and their condition (extent of erosion).

vi) Volumes of leachate collected, disposed of or treated.

vii) Performance of gas control facilities and information on any energy recovery operations.

viii) The condition of fences and site access.

ix) The condition of on-site roads.

x) The extent of litter, pests, noise, dust, odour and vibration on the site and in the surrounding area.

xi) The adequacy of cover material.

xii) Calculations of the remaining site capacity, including any cross-section drawings from elevation surveys.

xiii) Variances from the Site Design and Operations Plan.

xiv) Any complaints received regarding the operation of the site.

xv) If within five years of site closure, plans for establishing replacement site(s).

xvi) Financial assurance update.

e) Discussion and Analysis

Discussion and analysis of the environmental quality monitoring results and the site operations should be included. This should lead to early identification of the existing problems and possible problems with the design, operation and management of the landfill.

f) Recommendations

Upon analysis of the data and identification of problems, recommendations of sequence of actions and time schedule of implementation should be included. The possible recommendations may include the following:

i) Changes to the environmental monitoring program (monitoring frequency, parameters measured, sampling locations, etc.) to better assess the environmental impact. Identify maintenance that is needed for the upkeep of the monitoring network;

ii) Changes to the Design and Operations Plan for improved landfill operations or to rectify problems;

iii) Improving maintenance practices;

iv) Investigations required to better assess environmental impact;

v) Necessary remedial action; and

vi) Implementation of the contingency system.

4.25 SUMMARY OF OPERATIONAL PRACTICES AT LANDFILL SITES

The tables presented in this subsection provide a summary of typical landfill practices necessary to meet requirements stipulated by Acts, regulations, or otherwise necessary for approval. The tables also include operational features, beyond and above minimal requirements, but may be necessary due to site conditions in order to achieve good waste disposal practices. The tables are not intended as a comprehensive check-list covering all possible considerations in operation and management of landfill sites. **The requirements for a landfill site are determined on a site-specific basis, and upon approval of the site, described in the Certificate of Approval and the approved Design and Operations Plan.**

Feedback received from the past public consultation process indicated that landfill regulations and requirements were general and believed to be more applicable to larger landfill sites. Small municipalities have stated that it would be unreasonable to impose the same requirements of the large landfills for small and remote sites. Existing regulations and guidelines on waste management practices, including Regulation 347, do not provide distinctions between the operational standards for landfills of differing size. For the purposes of Subsection 4.25, the concept of categorizing landfill sites as small, medium and large is introduced to illustrate operational practices that can be implemented to achieve efficient and effective landfilling that will protect the environment and public health and safety. The tables should be especially useful with respect to small or medium sites.

Landfill sites are categorized as small, medium, or large based on its site capacity, with consideration given to using higher or lower level measures because of specific site conditions and proximity to, and nature of, surrounding land uses. The landfill capacities are based on an assumption of 20 years lifespan of the site. Regardless of site capacity or location, certain minimum operational controls are required. The main objective of landfill site categorization would be that all sites must conform to the minimum standards, however, for medium and large sites, more stringent requirements would apply. Regardless of the minimal operational standards specified in the tables, specific site conditions may allow lower requirements or dictate higher requirements at the discretion of the MOEE.

Small sites can be defined as those sites having a designed lifetime capacity of under 40,000 m^3 and serving populations less than 1,500 people. Generally, these sites would have considerably lesser potential for environmental degradation effects than medium or large landfill sites. For example, landfill sites owned/operated by rural municipalities or the Ministry of Natural Resources would generally fall under the small category.

Medium sites can be defined as sites having designed lifetime capacity of 40,000 to 200,000 m^3. This equates to servicing populations of approximately 1,500 to 7,500 people.

Large sites can then be defined as those sites having designed lifetime capacity in excess of 200,000 m^3 and serves a community of approximately 7,500 people or more.

Adjacent land uses of particular concern, for the purposes of this subsection, include the following existing or proposed land uses near the landfill site:

i) permanent structure used in animal husbandry;
ii) agricultural land for pasturing livestock; or
iii) permanent structure where
- a person sleeps, or
- a person is employed, full-time, for at least three months in a year, but not including food or motor vehicle service facilities adjacent to a highway, utility operations, scrap yards, heavy industrial uses, pits and quarries, mining activities or forestry activities.

LEGAL SURVEY OF THE SITE

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Legal Survey	Survey, undertaken by Ontario Land Surveyor, is prepared for all lands that are used for landfilling waste. Crown lands without legal descriptions are the exceptions, for which, general descriptions and plans of the sites are acceptable.		

** Refer to Subsection 4.2 for details

REGISTRATION ON TITLE

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Registration on Title	The Certificate of Approval is registered on land title for all existing and new landfill sites. For new sites, registration must be completed prior to waste deposition. Unpatented Crown lands are the exceptions, for which, MNR policies should be consulted.		

** Refer to Subsection 4.3 for details

HYDROGEOLOGICAL EVALUATION

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Evaluation and Report	Hydrological evaluation is completed to determine if the site is hydrogeologically acceptable for landfilling.	Hydrological evaluation is necessary for establishment and operation of landfill site.	Hydrological evaluation is necessary for establishment and operation of landfill site.
2. Content and Level of Detail	Content and level of detail are determined on site specific basis, but basic soil assessments including determination of soil properties and water table achieved by back-hoe and/or soil maps are acceptable.	Content and level of detail are determined on site specific basis such as the complexity of the hydrogeological system and consequences of site design failure.	Content and level of detail are determined on site specific basis such as the complexity of the hydrogeological system and consequences of site design failure.

** Refer to Subsection 3.5 for details

SITE OPERATIONS PLAN

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Site Operations Plan	Plan(s) outlines site development, operations, contingency plan, as well as closure and post closure. The Plan should address operational criteria listed in these tables.	Plan(s) details site development, daily operations,environmental control measures, monitoring program, contingency plan, as well as closure and post closure activities. The Plan should address operational criteria listed in these tables.	Plan(s) details site development, landfilling, daily operations,environmental control measures, monitoring program, contingency plan, as well as closure and post closure activities. The Plan should address operational criteria listed in these tables.
2. Preparation of Plan	The Plan can be prepared by the site owner/operator or by a professional knowledgeable in waste management and landfilling techniques.	A detailed and extensive Plan is prepared by professionals who are proficient in waste management and landfilling techniques.	A detailed and extensive plan is prepared by professionals who are proficient in waste management and landfilling techniques.

** Refer to Subsection 3.7 for details

BUFFER

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Operation, maintenance and monitoring	30 m minimum	30 m minimum	30 m minimum
2. Control and corrective measures	30 m	100 m	100 m
3. Nuisance controls	30 m	100 m	100 m
4. Physical separation	30 m	100 m	100 m

** Refer to Subsection 4.4 for details; and Regulation 347, Section 11

ON-SITE ROADS

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Road width	3 m for single lane traffic.	3 m (single lane) and/or 7 m for two way traffic.	Generally all on-site access roads should be 7 m wide for two way traffic.
2. Road surface	Compacted gravel or as appropriate.	Based on truck traffic, compacted gravel or as appropriate.	To support large heavy trucks, compacted gravel or asphalt on roads leading to site offices and main disposal areas.
3. Road drainage	Sloped road surface with roadside ditches.	Sloped or crowned road surfaces, roadside ditches, and culverts if necessary.	Crowned road surfaces, cross drains and culverts, stabilized ditches. Catch-basins with storm water drain pipes if necessary
4. Maintenance	Semi-annual grading and compaction. Emergency repairs year round. Snow clearance, if the site is operational during winter months. Cleaning of ditches semi-annually.	Monthly inspection; grading and compaction every quarter. Emergency repairs year round. On-site equipment for snow clearance. Quarterly clean-out of ditches.	Monthly inspection; grading, compaction, repair/restoration. Emergency repairs year round. On-site equipment for snow clearance. Regular clean-out of ditches, culverts, and drainage works, catch basins and storm sewers.
5. Dust control	Spraying surfaces with water when necessary. Waste oil is not permitted.	Spraying surfaces with water during high winds and as necessary. Waste oil is not permitted.	Regular use of approved dust control measures. Waste oil is not permitted.
6. Control of debris transported off-site	Instruction signs for drivers of leaving vehicles. If warranted, vehicle inspections.	Inspection of vehicles leaving site. Instructions on sign boards for trucks leaving site.	Truck washing facilities available on-site. Signs for drivers of leaving vehicles.

** Refer to Subsection 4.5 for details; and Regulation 347, Section 11

FENCING

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Perimeter Fencing	Natural topographic barriers, page or chain link fence.	Natural topographic barriers with page or chain link fence along adjoining roadways and elsewhere as needed.	Chain link or similar with minimum height of 1.8 m (6').
2. Security Fencing	Lockable gate at entrance.	Chain link fence at entrance with lockable gates and elsewhere as needed.	Chain link fence at entrance with lockable gates and elsewhere as needed.
3. Litter Fencing	As needed.	Moveable litter fences.	Moveable, with permanent litter fences in critical areas.
4. Other Fencing	According to Occupational Health and Safety Act (OHSA) or other regulations.	According to OHSA or other regulations, and as needed to control access to treatment or control works.	According to OHSA or other regulations, and as needed to control access to treatment, control or gas utilization works.

** Refer to Subsection 4.6 for details; and Regulation 347, Section 11

SIGNS

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. As a minimum, one sign at the public entrance(s)	Sign with basic information such as the identity of the owner/operator, time of operations and wastes accepted.	Sign with basic information such as the identity of the owner/operator, time of operations and wastes accepted.	Sign with basic information such as the identity of the owner/operator, time of operations and wastes accepted.
2. Signs along on-site roads	Directions to waste haulers and other users. Basic road safety and warning signs depending on frequency of use.	Directions to waste haulers and other users. Road safety speed limits, hazard warnings and other site-specific needs.	Directions to waste haulers and other users. Road safety speed limits, hazard warnings and other site-specific needs. Signs, hazard warnings, etc. are more frequent than at medium site.
3. Signs at waste disposal locations	Identify areas for unloading waste and stockpiling brush/wood or metal waste and other site-specific needs.	Site-specific, including instructions for disposal and segregation of recyclables	Site-specific, including instructions for disposal and segregation of recyclables with prominent warning signs.
4. Signs at leachate and gas control installations and at monitoring locations	As needed.	Site-specific, with warnings at all hazardous locations and control works.	Site-specific, but with more instructions, safety precautions and hazard warnings.

** Refer to Subsection 4.7 for details

SCREENING

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Extent of screening	Normally from roads, but depends upon distance to nearby land uses.	From roads and nearby land uses, but depends upon distance to nearby land uses	From roads, all nearby land uses, and general view.
2. Best location and types of screening measures	Generally in buffer area. Use of natural features and large separation distance is encouraged.	Generally in buffer area. Fencing & screening berms are usually adequate with natural features and large separation distances.	Generally in buffer area. Fencing & screening berms are usually adequate with natural features and large separation distances. Off-site measures may be needed on a site-specific basis.

** Refer to Subsection 4.8 for details; and Regulation 347, Section 11

SURFACE DRAINAGE

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Run-Off Analysis and analysis of capacity of receiving streams, drainage paths, or storm sewers to accommodate site run-off	Generally not needed.	Depends on site-specific conditions and land-use sensitivity, and significance of off-site watercourses.	Normally needed. To be undertaken by qualified water resources engineer or hydrologist.
2. Types of diversion structures	Ditches, and natural drainage swales, usually sufficient.	Ditches, culverts, diversion berms or dykes and natural drainage swales.	Engineered structures including drainage ditches, culverts, storm water catch basins and storm sewers, berms, retention ponds and natural drainage swales.
3. Methods of discharge off-site	Control structures are not needed if site topography, and geology and off-site land use permits to off-site drainage path, watercourse or municipal ditch.	Controlled discharge to off-site watercourse, drainage path or municipal ditches. Energy breaks, stone pitching, rip-rap protection may be necessary at outlet.	Controlled discharge off-site with energy breaks and erosion controls, to watercourse, preferably with permanent flow. Discharge to municipal storm sewer system.
4. Erosion and sedimentation controls	Stabilized ditches with seeded or sodded bed and slopes.	Stabilized, seeded or sodded ditches, straw bales in ditches, rock check dams, filter berms and sedimentation ponds.	Stabilized, seeded or sodded ditches, straw bales in ditches, rock check dams, filter berms, sedimentation ponds and other means.
5. Sedimentation pond	Generally not needed	Depends on site-specific conditions, off-site land use and importance of off-site watercourses, wetland, etc.	Generally needed, but depends on site-specific conditions, off-site land use and importance of off-site watercourses, wetland, etc.
6. Monitoring of water quality	In accordance with approved monitoring program.	Yes - in accordance with approved monitoring program.	Yes - in accordance with approved monitoring program.
7. Treatment prior to discharge	Generally not needed but depends on monitoring results.	Generally not needed but depends on monitoring results.	Depends on monitoring results and on local municipal storm water by-laws, or assimilation capacity of receiving stream.
8. Maintenance program	Generally, inspection and clean-out of ditches in spring and fall.	Quarterly inspection and clean-out of all drainage control works. Regular grading of fill areas.	Monthly inspections, quarterly clean-out of all drainage control works. Regular grading of fill areas. Clean-out of sedimentation ponds in accordance with approved maintenance program. Semi-annual check on integrity and stability of all drainage control works.

** Refer to Subsection 4.9 for details; and Regulation 347, Section 11

LEACHATE CONTROL

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Design Concept	Natural attenuation of the leachate.	Natural attenuation with leachate controls as required by site conditions.	Generally, leachate control facilities are needed.
2. Collection method (new sites)		Perimeter or underdrain collection system.	Perimeter or underdrain collection system.
3. Collection method (remedial actions)	Interceptor trench, toe drain, purge wells, barrier walls on a site-specific basis.	Interceptor trench, toe drain, purge wells, barrier walls on a site-specific basis.	Interceptor trench, toe drain, purge wells, barrier walls on a site-specific basis.
4. Access to system		Needed for cleaning, maintenance, contingency use.	Needed for cleaning, maintenance, contingency use.
5. Leachate handling - the level depends on: site conditions, leachate characteristic, and the availability of sewer system, wastewater treatment facilities and receiving water bodies	None needed - generally natural attenuation is adequate;	None needed if natural attenuation is adequate; or Collection, on-site pretreatment with discharge to sanitary sewer or haul off-site to WPCP.	Collection for off-site treatment; or Collection, on-site pretreatment with discharge to sanitary sewer or haul off-site to WPCP.
6. Approvals for leachate collection, treatment and haulage	EPA, Part V and Regulation 347.	EPA, Part V and Regulation 347.	EPA, Part V and Regulation 347.
7. Approvals for leachate treatment and off-site discharge.	Municipal consent for discharge to sanitary sewer or municipal WPCP. OWRA for discharge to storm sewer, watercourse, or water body.	Municipal consent for discharge to sanitary sewer or municipal WPCP. OWRA for discharge to storm sewer, watercourse, or water body.	Municipal consent for discharge to sanitary sewer or municipal WPCP. OWRA for discharge to storm sewer, watercourse, or water body.

Leachate control, including containment, collection, handling and treatment, is considered and assessed on a site-specific basis. When required, the methods employed should be state of the art using the best available technology that is economically available.

** Refer to Subsections 3.3 and 4.10 for details; and Regulation 347, Section 11

GAS CONTROL

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Gas migration control facilities	Generally not needed.	Site conditions determine the need.	Generally needed.
2. Preferred method to deal with migrating gas	Adequate buffer area.	Adequate buffer area.	Collection and flare or energy utilization.
3. Investigation for gas migration	Determine if the buffer is adequate in preventing off-site migration of landfill gas. As a rule, for each depth of waste fill, there is potentially 10 times lateral distance of significant gas migration. Determine extent and concentrations of gas migration, verify stratigraphy, locate water table, or bedrock surface, determine limit of fill Relate observed condition to seasonal changes.	As a rule, for each depth of waste fill, there is potentially 10 times lateral distance of significant gas migration. Determine extent and concentrations of gas migration, verify stratigraphy, locate water table, or bedrock surface, determine limit of fill. Relate observed condition to seasonal changes.	As a rule, for each depth of waste fill, there is potentially 10 times lateral distance of significant gas migration. Determine extent and concentrations of gas migration, verify stratigraphy, locate water table, or bedrock surface, determine limit of fill. Relate observed condition to seasonal changes.
4. Gas interceptor system - barrier, passive, or active	Generally not needed.	If needed, choice depends on - depth of excavation required, - sustained integrity of liner materials, - permeability and diffusion potential of adjacent native materials, - the ability to achieve negative pressure in the soil along the landfill boundary without or with the use of a fan.	Choice depends on - depth of excavation required, - sustained integrity of liner materials, - permeability and diffusion potential of adjacent native materials, - the ability to achieve negative pressure in the soil along the landfill boundary without or with the use of a fan.
5. Design standards for barriers, passive and active venting system	Generally, gas control facilities are not necessary.	As needed to prevent migration from landfill site.	As needed to prevent migration from landfill site; commonly designed to facilitate increase in volume of landfill gas over time (piping and fan capacities).
6. Safety considerations during construction	Generally, gas control facilities are not necessary.	Be aware of malodorous and combustible gases and follow a Health and Safety Plan.	Be aware of malodorous and combustible gases and follow a Health and Safety Plan.
7. Emission standards for gas control facilities.	Generally, gas control facilities are not necessary.	Set in a site-specific way by approval under Section 9 of EPA.	Set in a site-specific way by approval under Section 9 of EPA.
8. Contingency flaring	Generally not necessary.	Generally not needed, but depends on adjacent land use and emission level.	Generally needed, but depends on adjacent land use and emission level.

** Refer to Subsections 3.4 and 4.11 for details

CONTINGENCY PLAN

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Immediate response plan for fires, accidents, spills, etc	Preparation of site-specific plans and arrangements for outside assistance.	Preparation of site-specific plans and arrangements for outside assistance.	Preparation of site-specific plans and significant on-site capabilities.
2. Ground water contamination	Needs consideration.	Site-specific plan.	Site-specific plan.
3. Gas migration	Needs consideration.	Site-specific plan.	Site-specific plan.
4. Surface water contamination	Site-specific plan.	Site-specific plan.	Site-specific plan.
5. Equipment failure	Alternative operating plan, with arrangements to secure replacement equipment.	Alternative operating plan, with arrangements to quickly secure replacement equipment.	Backup capability needed on-site to avoid delays in waste disposal.
6. Financial assurance	Normally required for private site. May be required for municipal site.	Normally required for private site. May be required for municipal site.	Normally required for private site. May be required for municipal site.

** Refer to Subsection 4.12 for details; and Regulation 347, Section 11

SITE PREPARATION REPORT

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Site preparation report contents	Describe the readiness of the site to receive waste as per approved plans. The Report is normally required to be submitted to the MOEE prior to any deposition of waste at the site. Base, final contours. Site facilities and services. Identify geologic and other site conditions not envisaged during the design phase. Describe mitigative measures taken. Changes to the site design will require amendment to the C of A prior to construction.	Describe the readiness of the site to receive waste as per approved plans. The Report is normally required to be submitted to the MOEE prior to any deposition of waste at the site. Base, final contours. Where part of design, information on all facilities for the control, handling or treatment of leachate or landfill gas. Site facilities and services. Identify geologic and other site conditions not envisaged during the design phase. Describe mitigative measures taken. Changes to the site design will require amendment to the C of A prior to construction.	Describe the readiness of the site to receive waste as per approved plans. The Report is normally required to be submitted to the MOEE prior to any deposition of waste at the site. Base, final contours Where part of design, information on all facilities for the control, handling or treatment of leachate or landfill gas (including gas utilization). Site facilities and services. Identify geologic and other site conditions not envisaged during the design phase. Describe mitigative measures taken. Changes to the site design will require amendment to the C of A prior to construction.

** Refer to Subsection 4.14 for details

CELL COVER

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Frequency of cell cover application	Monthly. Cell cover may not be necessary during winter.	Daily basis, and weekly in certain cases based on site conditions.	Daily basis.
2. Daily soil cover thickness	150 mm	150 mm	150 mm
3. Intermediate soil cover thickness	300 mm	300 mm	300 mm
4. Use of material other than soil as daily or interim cover	Permitted on site specific basis but requires evaluation and MOEE approval of its suitability as cover material.	Permitted on site specific basis but requires evaluation and MOEE approval of its suitability as cover material.	Permitted on site specific basis but requires evaluation and MOEE approval of its suitability as cover material.

** Refer to Subsection 4.17 for details; and Regulation 347, Section 11

SUPERVISION

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Site personnel	Site Supervisor, Operator for all site work, note: positions may be shared by one or more persons	Site Supervisor, Site Technician, Foreman - Equip./Operation, Operators, alternating work on spreaders, scrapers and compactors, Weigh Scale Attendant (if scales are installed), Spotter at working face.	Site Supervisor, Site Engineer, Equipment Foreman, Working Face Foreman, Operators for spreaders and scrapers for daily cover, Operators for compactors, Weigh Scale Attendant and Clerks for billing, Spotters at working face.
2. Site personnel training	Basic Health and Safety and site inspection. WHMIS. Emergency response procedures and contingency plan implementation.	Basic Health and Safety, and site inspections, WHMIS, Regulation 347, operations of monitoring systems, control works and treatment plants. Emergency response procedures and contingency plan implementation.	Basic Health and Safety, and site inspections, WHMIS, Regulation 347, operations of monitoring systems, control works and treatment plants. Emergency response procedures and contingency plan implementation.
3. Site personnel facilities	Weather tight, heated, site office with a water supply and toilet facilities are desirable.	Site office, trailers with lockers, a pressurized water system, potable water and lunchroom and wash-up toilet facilities.	Site office, trailers with showers, lockers, pressurized water system, potable water, and wash-up toilet facilities, lunchroom, parking area.
4. Site supervision or inspection	Inspection of facilities and equipments for adherence to the approved Design & Operations Plan.	Supervision or inspection of staff, users, facilities and equipments for adherence to the approved Design & Operations Plan.	Supervision or inspection of staff, users, facilities and equipments for adherence to the approved Design & Operations Plan.

WHMIS - Workplace Hazardous Materials Information System, Regulation 644/88, under Occupational Health and Safety Act
** Refer to Subsection 4.18 for details; and Regulation 347, Section 11

HOUSEKEEPING

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Nuisance factors to be controlled	Noise, dust, litter, odour, vectors, vermin and scavenging bird and animals. Local municipal by-laws may impose more stringent requirements.	Noise, dust, litter, odour, vectors, vermin, scavenging birds and animals. Local municipal by-laws may impose more stringent requirements.	Noise, dust, litter, odour, vectors, vermin, scavenging birds and animals. Local municipal by-laws may impose more stringent requirements.
2. Housekeeping program	Spring and fall general clean-up with good site operational practices.	Site-specific program needed.	Site-specific program needed.
3. Control of specific landfill generated nuisance factors	Diligent inspection of the site with regular pick up of litter and use of litter fences down wind.	Good compaction and covering of waste is generally effective. Diligent inspection of the site and implementation of the housekeeping program.	Good compaction and covering of waste is generally effective. Diligent inspection of the site and implementation of the housekeeping program. Control measures will be more rigorous.
4. Vector and Vermin Control	Generally, contingency measures are adequate.	Routine pest control program may be necessary.	Routine pest control program is necessary.
5. Dealing with and resolving public complaints and concerns regarding nuisance	Good communication with local "landfill liaison committee". Expedite remedial measures and demonstrate willingness to co-operate.	Same as small site. Regularly employ professional for pest and disease control measures.	Same as medium site. Environmental officer or supervisory official of owner/operator to maintain contact with local "landfill liaison committee". Environmental updates, detailing housekeeping measures should be issued regularly.

** Refer to Subsection 4.20 for details

OPEN BURNING OF WASTE

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Open burning of waste	Open burning of waste at landfill sites is prohibited. Segregated, clean wood and brush, however may be burned at certain isolated sites subject to conditions.	Open burning of waste at landfill sites is prohibited.	Open burning of waste at landfill sites is prohibited.

** Refer to Subsection 4.21 for details

FINAL COVER

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Final cover	Soil cover of minimum 750 mm, with topsoil and vegetation, or approved alternate cover.	Soil cover of minimum 750 mm, with topsoil and vegetation, or approved alternate cover.	Soil cover of minimum 750 mm, with topsoil and vegetation, or approved alternate cover.
2. Slope	Minimum 5% and maximum 25%	Minimum 5% and maximum 25%	Minimum 5% and maximum 25%

** Refer to Subsection 4.22 for details; and Regulation 347, Section 11

MONITORING PROGRAM

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Components of a monitoring program	Monitoring of existing adjacent wells and/or watercourses is normally adequate.	(a) ground water, (b) surface water, (c) gas migration, (d) leachate, (e) liner (if installed).	(a) ground water, (b) surface water, (c) gas migration, (d) leachate, (e) liner (if installed).
2. .Stages	(a) Baseline Monitoring Program, (b) Operational Monitoring Program, (c) Post Closure Monitoring Program.	(a) Baseline Monitoring Program, (b) Operational Monitoring Program, (c) Post Closure Monitoring Program.	(a) Baseline Monitoring Program. (b) Operational Monitoring Program, (c) Post Closure Monitoring Program.
3. Monitoring Plan	Where required, (a) listing of devices to be used, (b) water quality parameters to be measured, (c) sampling and analytical procedures, (d) evaluation procedures, (e) implementation schedule.	(a) listing of devices to be used, (b) water quality parameters to be measured, (c) sampling and analytical procedures, (d) evaluation procedures, (e) implementation schedule, (f) Site-specific concerns for impacts on adjacent land use.	(a) listing of devices to be used, (b) water quality parameters to be measured, (c) sampling and analytical procedures, (d) evaluation procedures, (e) implementation schedule. (f) site-specific concerns for impacts on adjacent land use.
5. Data Records	Where required, (a) surface water quality, and (b) ground water quality. (c) changes in ground water levels.	(a) surface water quality, (b) ground water quality, (c) gas migration, (d) contaminant migration rate, (e) comparison to predicted contaminant levels. (f) changes in ground water levels.	(a) surface water quality, (b) ground water quality, (c) gas migration (d) contaminant migration rates (e) comparison to predicted contaminant levels, and (f) changes in ground water levels.

** Refer to Subsections 3.6 and 4.23 for details; Regulation 347, Section 11

STATUS REPORT

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Submission frequency	Annual or bi-annual, unless contamination has been measured requiring more frequent reporting.	Annual, unless contamination has been measured requiring more frequent reporting.	Annual, unless contamination has been measured requiring more frequent reporting.
2. Contents	(a) environmental quality monitoring, (b) operations monitoring, (c) analysis of data, and (d) recommendations.	(a) environmental quality monitoring, (b) operations monitoring, and (c) analysis of data, and (d) recommendations.	(a) environmental quality monitoring, (b) operations monitoring, and (c) analysis of data, and (d) recommendations.

** Refer to Subsection 4.24 for details

SITE CLOSURE

DESCRIPTION	SMALL LANDFILL	MEDIUM LANDFILL	LARGE LANDFILL
1. Closure Plan	Yes	Yes	Yes
2. Post-closure inspection and maintenance	Annually as a minimum.	Quarterly as a minimum.	Quarterly or more frequently if necessary.
3. Monitoring	Monitoring of existing adjacent wells and/or watercourses is normally adequate. Monitoring will generally be quarterly for at least the first two years and annually thereafter.	Site-specific monitoring program necessary. Monitoring will generally be quarterly for at least the first two years and semi-annually thereafter.	Site-specific monitoring program is necessary. Monitoring will generally be quarterly.
4. Control Works	Generally, continuation of existing control works, if any. eg, natural attenuation and buffer are normally sufficient.	Generally, continuation of existing control works, if any. eg, operation of leachate collection and treatment systems and gas control for as long as needed	Generally, continuation of existing control works, if any. eg, operation of leachate collection and treatment systems and gas control and energy utilization facilities for as long as needed

The Closure Plan should address all the pertinent and site-specific items listed in Subsection 5.1, regardless of site size. Larger, more sophisticated sites will generally require more detail than small, simple sites.

** Refer to Subsection 4.22 and Section 5

SECTION 5

CLOSURE OF LANDFILL SITES

5.1 SITE CLOSURE

5.1.1 Introduction

The after closure period is an important segment of the life of the landfill, and marks not only the end of operating life (typically twenty years), but the beginning of the after closure period which can last for decades to several hundreds of years. The landfill owner/operator must ensure that a closed site is aesthetically acceptable and will have minimal health and environmental impacts, as concerns associated with landfill sites such as leachate, landfill gas and uneven land settling will continue for many years. Equally important are the considerations for potential re-use of the closed site and compatibility with nearby land uses, thus providing an asset to the local community. Particularly with the changes to the municipal waste stream composition through diversion of biodegradable organics and recyclables from landfills, there can exist greater opportunities to use the closed landfill sites for other activities that the local community desires. The closure of the site should be planned from its inception to ensure landfill design and operations support the intended end use.

5.1.2 General Requirements

Site closure activities involve the progressive rehabilitation of a landfill, as portions of the fill area reach final approved contours. Closure of small sites may only require the application of final cover and continued long-term monitoring and maintenance. Closure of larger sites may require continued operation of leachate and gas control systems to prevent unacceptable environmental impact on adjacent lands.

A detailed final Closure Plan documenting closure procedures and the intended end-use of the site should be submitted to the MOEE for approval at least two years prior to site closure, or as specified in the Certificate of Approval. (As a matter of good practice, planning for a replacement landfill or an alternative disposal method should be initiated at least 5 years prior to the closure of the site.) The Closure Plan should be in general conformance with the conceptual Closure Plan originally submitted as part of the Design and Operations Plan. Any proposed changes to the initial concept must be clearly documented. The Certificate of Approval requires amendment to reflect the closure and post closure activities.

Implementation of a staged Closure Plan throughout the life of the landfill will provide the site operator with several advantages including the following:

a) The ability to progressively cap and close parts of the landfill site during its active life;

b) The potential to obtain low cost final cover materials, which might be obtained from construction projects with surplus excavated materials;

c) The ability to establish vegetative cover progressively, and strategically plant smaller, less expensive trees than may otherwise be required at closure and to actively maintain closed portions of the site while staff and equipment are readily available;

d) Where intended by the landfill design, reduction of the quantity of leachate produced at the site by reducing infiltration as a consequence of the installation of low permeability final cover; and

e) Apportioning closure costs over the life of the site rather than incurring all costs at one time. Similarly, financial assurance for after closure care may be already established.

Accordingly, efficient and economic closure of a landfill site requires long-term planning and should consider: end-use of the site; ground water and surface water control; gas and leachate control and management; settlement of the fill area; long-term maintenance and site monitoring needs; and financial assurance.

5.1.3 Closure Plan

The final Closure Plan, submitted to the MOEE for approval, should contain detailed site information, including proposed final contours, leachate and gas control systems in place or required, remedial works to be installed, landscaping, monitoring and maintenance requirements, procedures, plans and proposed timetable for closing the site. Phased or progressive site closure is recommended and may be specified in the Closure Plan.

Since waste within the landfill will continue to generate gas and leachate and settlement of the fill area will continue to occur for many years following site closure, engineered Closure Plans should consider these factors and their impact on the final end-use of the property.

The following details the areas of concern, leachate, gas, settlement, end use, vegetation, maintenance and monitoring, that require specific attention in the Closure Plan.

a) Leachate

Leachate will continue to be produced for many years after the closure of the landfill, and its impact on the environment, in particular upon the neighbouring land uses, must be minimized or otherwise controlled within the approved criteria. The leachate management strategy employed at landfill sites is to control the volume and rate of leachate generation. It is this

volume and rate of leachate generation that has to be naturally attenuated or collected for treatment/disposal.

A common strategy involves low annual generation of leachate, thereby reducing the annual cost of leachate collection and treatment, both during the active site life and after closure. Low permeability final cover is placed as soon as practical after final waste contours are established to reduce water infiltration; vegetative cover with high evapotranspiration is established; the slopes are graded to promote run-off. However, drawbacks of such a system is the decrease in the rate of waste decomposition and landfill stabilization and thereby extending the contaminating life of the landfill.

Following site closure, the overall integrity of the final cover should be routinely inspected and maintained to ensure performance to the design specification in controlling the infiltration of surface water into the landfill.

The leachate control system in place or proposed, its operation and maintenance, and the monitoring program should be clearly defined in the Closure Plan.

b) Landfill Gas

Landfill gas will continue to be generated from waste decomposition for many decades following site closure. Landfill gas must be prevented from migrating in the subsurface beyond the site boundaries or towards structures, where it may accumulate. The preferred method of dealing with landfill gas migration is to provide adequate buffer area that will allow for natural attenuation (natural venting) to the atmosphere. At most of the existing landfill sites in Ontario, the buffer area prevents significant off-site migration. Where the buffer area does not adequately protect the adjacent land uses, engineered gas control facilities are required. Requirements for dealing with the migration of the landfill gas, including the need for any engineered gas control system, should be determined on a site specific basis.

Difficulties may arise, particularly at the fill area, with surface emissions of landfill gas which may result in offensive odours. Furthermore, vegetative stress may develop due to gas movement within the final cover. Remedial actions to deal with these types of concerns should be addressed in the Closure Plan. Frequently, repair to the final cover system may be all that is required.

Installation of relatively impermeable final cover may promote gas migration laterally through the subsurface and into adjacent structures, both on and off-site, potentially creating a fire or explosion hazard. Design of gas control systems, final cover systems and monitoring plans must address these issues.

Where gas collection systems are in use, their operation and maintenance, and the monitoring programs should be defined.

c) Settlement

Decomposition of waste materials will continue for decades following site closure. The differential settlement resulting from this process is neither uniform nor predictable. Additionally, settling of any loosely compacted or non-compacted waste is a contributing factor. Wide cracks that develop in the cover as a result of settlement could result in excessive infiltration of precipitation with increases in leachate quantities and in the escape of landfill gases and odours. In addition, if the integrity of the final cover is lost, the underlying wastes could become exposed to vectors and vermin.

Regular regrading and maintenance of the landfill surface is necessary to control the above and to maintain site drainage patterns. Details of inspection and maintenance plans are to be included in the Closure Plan.

d) End Use

With careful planning, siting, design and management, alternative beneficial end use can always be realized from lands that have been used for landfilling of municipal waste. Many of the land uses, prior to landfilling at the site, can again be possible with careful consideration of the hazards and control measures associated with closed landfill sites. Further, it may be possible to close the site in a manner that will return the site to its former land use. The MOEE Policy 07-07 provides information on issues that should be addressed in proposals for land use on or near landfill sites.

Beneficial end use is encouraged, however, the landfill owner and operator must carefully design and implement the closure activities, as well as, monitor and maintain the closed site to ensure the safe end use of the site and its compatibility with nearby land uses of the area. Section 46 of the EPA requires that no use be made of land used for the disposal of wastes within a period of 25 years from the year in which it ceased to be so used, unless approval for the proposed use has been granted by the Minister. The change of land use from a landfill to an alternative beneficial end use, requires Section 46 approval. The proposed end use of the site is normally required to be clearly stated and detailed in the Closure Plan.

A completed landfill may be converted into a green area or public park, golf course, ski hill, picnic area or other passive, recreational use for the pleasure of the community.

Agricultural end use may also be possible at closed sites. In addition to health and environmental considerations, design factors for re-establishment of land that could support agricultural use could be included. For example, thicker final cover layers may be required to allow for long root systems which some crops develop. As well, the topsoil and subsoil should be restored in a manner (drainage, nutrient content, etc.) that would support such an end-use.

e) Vegetation (and Final Cover)

Vegetation plays an integral role after the closure of the landfill site:

i) maintains the integrity of the final cover, primarily by preventing water and wind erosion;
ii) controls evapotranspiration and thereby water infiltration and leachate generation; and
iii) function as a component of the designed end use of the land. Its simplest function is to provide aesthetic landscape to the site.

Landscaping and vegetation on the final landfill surface may be affected by elevated soil temperatures caused by waste decomposition and elevated level of landfill gas in the root zone. Shallow rooted plants are usually better able to withstand these effects without stress. Additional thickness of soil around roots can help trees to survive gas impacts.

The proposed end-use and landscaping of the site therefore have a bearing on final cover system. Final cover is discussed in Subsection 4.22.

f) Maintenance and Monitoring

Once the approved Closure Plan is implemented, the post-closure environmental monitoring, site inspection and maintenance program as specified in the Certificate of Approval continues until when the landfill has stabilized or until it can be shown that the site no longer possesses the potential for unacceptable impact on the environment or on public health and safety.

Long-term site maintenance, site inspection and monitoring requirements may vary at different phases of site closure. For example, as monitoring data are accumulated over time, the frequency of data collection may be reduced at the discretion of the MOEE.

All engineered control facilities, including monitoring facilities, are normally required to function for the contaminating life of the landfill; they should be maintained, repaired or replaced where they are necessary. This matter is further described in MOEE Policy 14-15 "Engineered Facilities at Landfills that Receive Municipal and Non-Hazardous Wastes".

5.1.4 Phases of Closure

The process of site closure normally involves three phases:

Phase 1 - period immediately proceeding site closure;
Phase 2 - short-term period, approximately 2 years, immediately following site closure;
Phase 3 - long-term period following site closure, with an indefinite time frame.

a) Phase 1

The first phase of closure occurs shortly before the site is closed. It consists of two segments: preparation and submission of a Closure Plan; and activities on-site and associated with the site to ensure protection of the public and the environment.

The final Closure Plan is a technical document which is normally required for submission to the MOEE for approval prior to implementation. It will generally provide details of the following:

i) final site contours and drainage plan;
ii) operations plan up to site closure;
iii) details on final grading, cover systems and source of cover materials;
iv) vegetative cover, landscaping plans and end-use of the site;
v) leachate and gas control systems in place or required;
vi) operation, maintenance and monitoring of leachate and gas control systems;
vii) ground water and surface water monitoring programs and schedules;
viii) gas monitoring programs and schedules;
ix) plans of general site clean-up;
x) rodent control requirements;
xi) details of immediate remedial works that are required;
xii) proposed maintenance schedules and details of same;
xiii) anticipated costs of closure and after closure care;
xiv) update of financial assurance; and
xv) contingency plans for ground and surface water quality protection and gas migration control.

Detailed drawings showing all existing site-services including roads, leachate and gas control systems, locations of observation and monitoring wells and gas probes, sedimentation ponds, final grading plans and other appropriate site-specific information, including locations of building foundations, should be included as part of the Closure Plan. This is particularly important since long-term maintenance activities may be conducted by persons unfamiliar with the site.

The second segment of Phase 1 deals with activities on-site and associated with the site to ensure protection of the public and the environment including the following:

i) preparing for start-up and operation of a new site or alternative disposal arrangements;
ii) notifying regulatory agencies of the precise closure date;
iii) informing the public of closure of the facility;
iv) posting signs around the site stating that the site is, or will be, closed;

v) implementing rodent control and baiting program if needed, and posting signs indicating use of rodent control poisons, etc.;
vi) implementing remedial works for gas and leachate control;
vii) collecting litter and debris and placing it in the landfill;
viii) covering exposed refuse;
ix) rough grading and final refuse compaction;
x) final cover application;
xi) constructing surface drainage control and establishing vegetation;
xii) information of any special waste buried and its location; and
xii) any other pertinent site-specific matters.

b) Phase 2

During Phase 2 of closure, which usually lasts about two years following the closure of the site, there will be a need to complete some of the activities of Phase 1 and to conduct regular site maintenance, inspection and monitoring to identify any potential environmental impacts (e.g., migrating leachate or gas) and to establish any action that may be required to mitigate such impacts. The information obtained during the second phase can be used to develop the long-term care program that will be required in Phase 3.

Generally, during the first few months of the second phase, activities will include the following

i) completing application of final cover and vegetation;
ii) completing drainage control features; and
iii) installing, if needed, remedial leachate and gas control works.

At a minimum, quarterly site visits should be made during the first two year period after closure to examine the following:

i) operation of leachate and gas control works (more frequently, if necessary);
ii) integrity of the final cover;
iii) condition and operation of the drainage ditches and controls;
iv) adequacy of fencing, gates, access roads;
v) side slope inspection and repair of leachate seeps and eroded areas; and
vi) water quality monitoring; and
vii) monitoring for gas migration.

The results of this program should be used to indicate the need for further control works and to establish the long-term maintenance and monitoring needs.

c) Phase 3

The third phase consists of the long-term care program that will be undertaken to assure that the environmental integrity of the landfill is maintained. The extent of the program is defined during the second phase. Major elements of the program should include the following

i) ground water and surface water monitoring;
ii) gas monitoring;
iii) leachate and gas control system monitoring and operation;
iv) implementation of remedial measures as needed to ensure cover integrity, leachate and gas control;
v) maintenance of drainage systems, vegetation, site aesthetics; and
vi) annual submission of monitoring and maintenance reports to the MOEE for review.

The frequency of monitoring and maintenance programs may be reduced with time during Phase 3, depending on the previous monitoring results and upon approval by the MOEE Director.

d) Annual Reports

The annual or status reports submitted after the site closure are essentially the continuation of the status reports that were submitted during the operational life of the landfill site. Similar issues, as described in Section 4.24, should be addressed with the obvious omission on details of active landfilling matters. However, an emphasis should be placed on the analysis and interpretation of the monitoring data and any subsequent conclusions and recommendations pertaining to monitoring, maintenance and contingency measures.

The status reports should include details of the extent of closure and site rehabilitation to date, the nature and extent of work to be undertaken in the following year, any changes in site conditions or planned uses that may affect the effectiveness of the Closure Plan, the results and interpretation of the monitoring undertaken and recommendations with regard to future work or monitoring.

An annual submission is normally required, however, more or less frequent submissions can be required at the discretion of the MOEE as circumstances dictate.

APPENDIX I

GLOSSARY OF TERMS

The definitions contained herein should not be interpreted as legal descriptions of the terms and phrases used in this Guidance Manual. They are intended only to provide an understanding of the terminology used in the context of landfill practices in Ontario.

Active Face (Working Face)

The portion of the landfill site where waste is currently being deposited, spread and/or compacted prior to the placement of cover material.

Aerobic Process

Biological process (decomposition or treatment) that occurs in the presence of oxygen.

Adverse Environmental Impact

Any direct or indirect undesirable effect on the environment resulting from an emission or discharge, which is caused or likely to be caused by human activity.

Anaerobic

Biological process (decomposition or treatment) that occurs in the absence of oxygen. e.g., decomposition of landfilled waste with consequent generation of methane gas.

Annual Report (or Status Report)

Report documenting the results of water quality, environmental quality, and operations monitoring for the year or for a period as prescribed in the Certificate of Approval.

Applicant

A person, private organization or a municipal authority applying for approval to establish and operate a new landfill, to expand or extend an existing landfill or to change an already issued Certificate of Approval.

Approved Design and Operations Plan

A Design and Operations Plan that has received formal approval of the MOEE, through the issuance of the Certificate of Approval. A Plan is submitted as part of the application for the Certificate, and once approved, the Plan is a supporting document to the Certificate of Approval.

Aquifer

A saturated permeable geologic unit (soil or rock) that can transmit significant quantities of water under ordinary hydraulic gradient. It is normally permeable enough to yield economic quantities of water to wells.

Aquitard

A geologic unit (soil or rock) that restricts the flow of water.

Attenuation

Natural process by which the concentrations of landfill generated contaminants are reduced to safe levels.

Bailing

Removal of water from a well with a bailer.

Baling (of Waste)

Compaction or densification of waste into blocks.

Baseflow

The water contribution to streams from subsurface flow routes following infiltration into the soil.

Biodegradable

Possessing the potential to decompose through natural or induced activity of micro-organisms.

BOD - Biochemical Oxygen Demand

A parameter that is widely used to determine or describe the organic content of water or wastewater. It is a measure of the dissolved oxygen used by the micro-organisms in organic matter.

Buffer Area

Area of land surrounding the fill area(s), but limited in extent to the landfill property boundary, assigned to provide space for remedial measures, contaminant control measures, and for the reduction or elimination of adverse environmental impact caused by migrating contaminants.

Cell

A space or contained area within the active fill area identified and prepared for receiving waste during any stage of landfilling, and subsequently compacted, enclosed by soil or other cover material.

Certificate of Approval

The permit issued by the MOEE for the use, operation, establishment, alteration, enlargement, or extension of a landfill site. It is issued to the owner of the site with terms and conditions of compliance stated therein.

Clay

Fine grained cohesive soil with particle size not greater than 0.005 millimetres.

Closure Plan

Document detailing the process of closing a landfill site at the end of its' active life. This document also includes post-closure requirements such as long-term monitoring.

Collection Basin Lysimeter

A device which is constructed with a geomembrane to monitor the unsaturated zone.

Composting

A controlled method of decomposing organic matter by the natural activity of micro-organisms to yield a humus-like product, usually for soil enrichment purposes.

Conservation Area

Watershed area requiring protection and conservation, through the administration of the Conservation Authorities Act by the Ministry of Natural Resources and the local Conservation Authority.

Contaminant

A compound, element or physical parameter, resulting from human activity, or found at elevated concentrations, that have or may have a harmful effect on public health or the environment.

Contaminant Migration Path

Route by which a contaminant will move from the site into adjacent properties or the natural environment. Usually a route that offers the least resistance to movement.

Contamination Attenuation Zone

The zone beneath the surface, located beyond the landfill site boundary, where contaminants will be naturally attenuated to predetermined levels. Also see Reasonable Use Policy.

Contingency Plan

A documented plan detailing a coordinated course of action to be followed to control and remedy unforseen occurrences that could threaten the environment and public health.

Cover Material

Material approved by the MOEE that is used to cover deposited waste. Its use may be for daily, interim or final cover.

Design and Operations Plan (Report)

Design and Operations Plan is the document detailing the landfill design and the planned sequence of activities including site preparations, daily operations, environmental control measures, site development and closure, post closure monitoring and maintenance. Also see Approved Design and Operations Plan.

Design Capacity

The maximum amount of waste that is planned to be disposed of at a landfill site.

Detection Limit

Concentration under which a parameter cannot be quantitatively measured.

Discharge Structure

Structures constructed to control and regulate the flow of surface run-off discharged off-site.

Diversion Structure

Structures intended to intercept and convey surface water run-off away from or around active fill areas.

EAA or EA Act

Environmental Assessment Act, Revised Statutes of Ontario, 1980, Chapter 140. One of the primary acts of legislation intended to protect, conserve and wisely manage Ontario's environment through regulating planning and development.

Effluent

Any liquid and associated material discharged into a surface watercourse or discharged on land as a means of final disposal.

EFW - Energy From Waste

The process of converting used or waste material into fuel or any form of energy.

EPA

Environmental Protection Act, Revised Statutes of Ontario, 1980, Chapter 141. EPA is the primary provincial legislation governing the protection of the natural environment of the Province.

Evapotranspiration

The evaporation from all water, soil, snow, ice, vegetation and other surfaces, including the transpiration of water by plants, that is released to the atmosphere as vapour.

Feasibility Report

A report documenting a rational, qualitative and quantitative comparison of the advantages and disadvantages of alternative landfill sites selected during the site selection process.

Fill Area

The part of a landfill site designed and designated for the disposal of waste.

Final Cover

Soil material or soil in combination with synthetic membranes, overlain by vegetation in a planned landscape, placed over a waste cell that has reached the end of its active life.

Floodplain

An area, usually low lands, adjoining a watercourse which has been, or which may be covered by flood water.

Flux

Rate of flow, for example landfill gas, across a given area.

Fly-ash

Particulate matter removed from combustion flue gases.

Gas Collection System

An engineered system to contain and collect migrating landfill gas for safe dissipation, for energy recovery or incineration.

Gas Extraction Well

A constructed well, within or outside the waste disposal areas, intended to draw in landfill gas for collection. Gas extraction wells are part of a landfill gas collection system.

Geomembrane

A highly impermeable synthetic membrane made of plastic or rubber-based material.

Geotextile

A porous fabric manufactured from synthetic materials.

Ground Water

Subsurface water that occurs beneath the water table in soils and rocks that are fully saturated.

Hazardous Waste

Any waste that is defined as hazardous to human health or the environment as defined by Ontario Regulation 347.

Hydraulic Conductivity

The rate of flow of water through a cross-section under a specific hydraulic gradient. It is a property of the geologic formation and the fluid, in hydrogeologic applications where the fluid is water. (units of m/day or cm/s)

Hydraulic Gradient

The head drop per unit distance in the direction of flow, and is the driving force for ground water flow.

Hydrogeologist

A person knowledgeable in the principles of hydrogeology.

Hydrogeology

The study of subsurface waters and related geologic aspects of surface waters.

Impermeable Fill

Soil material that is placed as filling material that is sufficiently cohesive and fine grained to impede and restrict the flow of water through it.

In-situ Testing

Testing done on-site, in the field, of material or naturally occurring substances in their original state.

Incineration

Controlled burning of solid waste for the purpose of waste destruction and/or achieving volume, weight reduction or to change waste characteristics.

Industrial Waste

Any waste that is the direct or indirect by-product of the manufacturing of a product or the performance of a service by industry or business. Note: This Guidance Manual is not applicable to waste disposal sites receiving liquid industrial or hazardous waste.

Land Use Compatibility

A desirable situation where land uses are located so as to avoid or minimize any significant adverse environmental effect of those land uses, upon one another.

Landfilling

Under Regulation 347, it is the disposal of waste by deposit, under controlled conditions, on land or on land covered by water, and includes compaction of waste into a cell and covering the waste with cover material at regular intervals.

Landfill Gas

Gas (primarily methane and carbon dioxide) generated by the decomposition of organic waste materials.

Landfilling Site

A parcel of land where solid waste is disposed of on land. under controlled conditions, for the purposes of waste management.

Leachate

Water or other liquid that has been contaminated by dissolved or suspended particles due to contact with solid waste.

Leachate Breakout

Location where leachate comes to the ground surface as a seep or spring.

Leachate Collection and/or Treatment System

A system where landfill produced leachate is collected and treated to remove contaminants prior to its release to the environment.

Leachate Monitoring System

A system of strategically placed wells or other measuring devices for scrutinizing and assessing qualitatively the movement of leachate and its effect on adjacent ground and surface water resources.

Leachate Plume

Ground water, beyond the waste fill limits, that has been impacted by the leachate from a landfill site.

Limit of Filling

The outermost limit at which waste has been disposed of, or approved or proposed for disposal at a landfill.

Liner

A constructed continuous layer of reworked natural soil (usually clay), or synthetic materials placed beneath and on the sides of a landfill, or waste cell that restricts the downward or lateral migration of leachate or landfill gas.

Lysimeter

Generally, large containers of soil set in the field to represent prevailing soil and climatic conditions used for the purpose of obtaining data on in situ conditions.

Manifest

A legal transport document, obtained from licensed waste haulers (issued through the MOEE), listing the items of hazardous and/or liquid industrial waste, as classified by Ontario Regulation 347, that are being transported.

Manifested Waste

A waste (usually liquid industrial waste or hazardous waste) for which a manifest is required for the transportation of that waste.

Methane Gas

An odourless, colourless, highly combustible and potentially explosive gas that is lighter than air, produced as a by-product of the process of decomposition of organic wastes.

Ministry

For the purpose of this Guidance Manual, the Ontario Ministry of Environment and Energy.

MISA

Municipal Industrial Strategy for Abatement. A program developed by the MOEE for the regulation of the quality of effluent and discharges, and intended to protect human health and the environment by enforcement of rigorous quality control standards.

MOE

Ontario Ministry of the Environment (presently Ontario Ministry of Environment and Energy).

MOEE

Ontario Ministry of Environment and Energy.

Monitoring

Regular or spontaneous procedures used to methodically inspect and collect data on the performance of a landfill site relating to environmental quality (i.e., air, leachate, gas, ground or surface water, unsaturated soils, etc.).

Monitoring Well

A water well used for the purpose of monitoring ground water conditions.

Municipal Waste

Under Ontario Regulation 347, municipal waste means any waste, whether or not it is owned , controlled or managed by a municipality, except, hazardous waste, liquid industrial waste, or gaseous waste, and solid fuel, whether or not it is waste, that is derived in whole or in part from the waste included above.

In a general sense, municipal waste refers to materials discarded by individuals in the course of their daily activities at home and by industries and business as a result of their normal operating activities, but not including liquid industrial waste or hazardous waste.

Multi-level Piezometer

A piezometer that allows ground water properties to be measured and samples to be taken at multiple elevations at one location.

Multiple Liners

A system of layers of reworked natural soil or artificial materials or a combination of both, placed beneath or on the sides of a landfill or waste cell that restrict the downward or lateral movement of solid waste, leachate or landfill gas.

Native Soil

Soil material occurring naturally in the ground at a location.

Natural Attenuation

Situation where contaminants are reduced to acceptable concentration levels by natural mechanisms. e.g. dilution, adsorption onto the soil matrix, biological action, and chemical interaction

Nitrification

A two stage biological treatment process by which ammonia is converted first to nitrite and then to nitrate.

Non-Combustible Material

Materials that will not support combustion in the ambient atmosphere.

Observation Well

See Monitoring Well.

Occupational Health and Safety Act

The primary act of legislation enacted by the Ontario Ministry of Labour to regulate and control the safety in the workplace, also Occupational Health and Safety Act, Revised Statutes of Ontario, 1980, Chapter 321.

Odour Control

Minimizing or eliminating the nuisance and undesirable impact of objectionable or unpleasant odours arising out of waste disposal operations.

Open Burning

Burning any matter whereby the resultant combustion products are emitted directly to the atmosphere without passing through an adequate stack, duct, or chimney.

Operations Plan

A document detailing the waste disposal operations in a planned manner that ensures compliance with regulatory provisions concerning the operations of a landfill site.

Operator (Site Operator)

The individual or organization who, through ownership or under contract, manages and operates a landfill site for the purpose of waste disposal. The 'Operator' can refer to the manager, shift supervisor, dozer operator, etc.

Organic Matter

Material of organic origin (animal or plant).

Owner

A person, persons, organization or municipal authority who own a landfill site, and in whose name the Certificate of Approval for the site is issued.

Percolation

The movement of water through soil or other solid medium.

Permeability

Often used interchangeably with hydraulic conductivity, but not strictly correct. Permeability is a property of the porous media only. Dependant upon media properties that affect flow, diameter, sphericity, roundness and packing of the grains.

Piezometer

A device for the measurement of hydraulic head, specifically, a pipe in which elevation of water level can be determined.

Piezometer Nest

A number of piezometers completed at various elevations at one location.

Pollutant

See Contaminant.

Post Closure or Post Closure Care

The stage of a closed landfill site and the actions taken for the care, maintenance and monitoring of a site after closing.

Processing Facility

A facility at which solid waste is shredded, baled, pulverized, composted, separated, combusted or otherwise treated, or altered by some means to facilitate further transfer, processing, utilization or disposal.

Provisional Certificate of Approval

Same as Certificate of Approval.

Public Hearing

A quasi-judicial process, whereby the public or any affected parties have the opportunity to voice concerns or otherwise address studies and the planning process carried out by the proponent.

Purge Well

A drilled well equipped with dedicated pumps to allow pumping down of the water table or leachate level to promote flow toward the well.

Reasonable Use Policy (Concept)

A policy developed by the MOEE to stipulate limits to the level of ground water quality impairment that may be permitted to occur at site property boundaries, to allow the reasonable use of adjacent properties or land without adversely affecting public health and the environment.

Recharge Zone

The portion of the drainage basin in which the net flow of ground water is directed away from the water table.

Recycling

Sorting, collecting or processing waste materials that can be used as a substitute for the raw materials in a process or activity for the production of (the same or other) goods. For example, the 'Blue Box' system, in-plant scrap handling, or raw material recovery systems. Recycling is also the marketing of products made from recycled or recyclable materials.

Recycling Facility or Plant

A facility where recycling of used or waste material is carried out.

Reduction (of waste or component of 3Rs program)

Those actions, practices or processes which result in the production or generation of less waste.

Refuse

See Waste.

Registered Professional Engineer

A licensed engineer (P.Eng.) in the Province of Ontario upon whom this designation has been conferred by the Professional Engineers Ontario (PEO) association as a competent and qualified professional.

Remedial Action

Corrective action taken to clean-up or remedy a spill, an uncontrolled discharge of a contaminant, or a breach in a facility or its operations, in order to minimize the consequent threat to public health and the environment.

Representative Sample

A small portion of soil, water, etc. which can be subjected to testing and analysis, that is expected to yield results that will reliably represent the identical characteristics of the source of the material or of a larger body of material.

Resource Recovery

Salvaging of valuable resources from waste material. Resource methods include recycling of used products to provide material for manufacturing and the conversion of waste to energy (EFW or Energy From Waste).

Reuse (component of 3Rs program)

The use of an item again in its original form, for a similar purpose as originally intended, or to fulfil a different function.

Run-off

The part of precipitation (rainwater, snowmelt) that flows overland and does not infiltrate the surface material (soil or rock).

Saturated Zone

The zone of a subsurface soil where all voids are filled with water.

Seasonal Population

The seasonal transient population in addition to the year round population, of a community or region.

Sedimentation

The deposition of fine grained soil in an undesirable location, as a result of scouring, erosion and transportation of earth materials by surface run-off.

Sedimentation Pond

An impoundment with a natural topographic depression, man made excavation, or dike arrangement that is used to control and minimize sedimentation off-site that would cause an adverse environmental effect.

Sensitive Land Use

A land use where humans or the natural environment may experience an adverse environmental impact from human activity including the landfill site.

Settlement

The subsidence of the top surface and underlying waste of a landfill or waste cell under its own weight.

Silt Curtain

A fabric, or other barrier system such as booms arranged in a manner to intercept and collect silt being transported in a watercourse, drainage channel or other diversion structure.

Silting

Deposition of silt through sedimentation.

Site Capacity

The maximum amount of waste that is planned to be disposed (design capacity) or that has been disposed of at a landfill site.

Site Closure

The planned and approved cessation or termination of landfilling activities at a landfill site upon reaching its site capacity.

Site Life

Normally refers to the period of time the landfill site is actively receiving wastes for land disposal, including and up to site closure.

Sludge

A solid-liquid like material. In the context of landfill sites, sludge commonly refers to any solid, semi-solid, liquid waste generated from municipal, commercial or industrial wastewater treatment plant, water treatment plant or air pollution control facility.

Solid Waste

Any waste matter that cannot be characterized by its physical properties as a liquid (or gas).

Source Separation

The separation of various wastes at their point of generation for the purposes of recycling or further processing.

Standpipe

A well point that reflects the top of the zone of saturation in the ground.

Storm Water

Run-off that occurs as a direct result of a storm event or thaw.

Storm Water Detention

Control of storm water by the construction of impoundments or structures for the purpose of regulating storm water flows during high intensity rainfall events, that would otherwise transport excessive amounts of sediment, cause soil erosion or cause flooding.

Stratigraphy

The geologic sub-structuring, usually layered with different distribution, deposition and age.

Surface Run-off (Drainage)

See Run-off.

Surface Water

Water that occurs at the earth's surface (ponds, streams, rivers, lakes, oceans).

Sub-soil

Soil horizons below the topsoil.

Topsoil

The uppermost layer of the soil containing appreciable organic materials in mineral soils, and typically has adequate fertility to support plant growth.

Transfer Facility or Station

A facility where solid wastes are brought by smaller refuse collection vehicles and transferred to larger trucks to be hauled to a disposal site, processing facility or resource recovery facility.

Unsaturated Zone (also Vadose Zone)

The zone in a porous sub-soil, where the voids are not completely water-filled, but contain some air-filled voids. Limited above by the land surface and below by the water-table.

Vector

A disease carrier and transmitter, usually an insect or rodent.

V.O.C. - Volatile Organic Compounds

Organic compounds which will readily volatilize (convert from liquid to gas phase) at conditions normally found in the environment.

Waste

Under the Environmental Protection Act, waste includes ashes, garbage, refuse, domestic waste, industrial waste, or municipal refuse and other used products as are designated in the regulations.

In a general sense, waste may be commonly described as material its owner no longer wants and is intended for disposal or to be given away (sometimes sold for nominal amount of money).

Waste Disposal Site

Any land or land covered by water upon, into, in or through which, or building or structure in which, waste is deposited or processed and any machinery or equipment or operation required for the treatment or disposal of waste.

Waste Management System

All facilities, equipment and operations for the complete management of waste, including the collection, handling, transportation, storage, processing and disposal thereof, and may include one or more waste disposal sites.

Water Table

Surface of the ground water at which the pressure is atmospheric. Generally the top of the saturated zone.

Water Balance

Amounts of water to various components in a system so that the amount of water entering the system equals the amount of water contained within and discharged out of a system.

Well Casing

The pipe that is used to construct a well.

Well Nest

See Piezometer Nest.

Well Screen

A filtering device used to keep sediment from entering a well.

Wetland

Area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrolytic vegetation, and which have soils indicative of wet conditions.

White Goods

Discarded household appliances and other large abandoned enamelled appliances.

Working Face

See Active Face.

APPENDIX II

REFERENCES - GOVERNMENT LEGISLATION, REGULATIONS, MOEE POLICIES AND OTHERS

A. Relevant Statutes of Legislation

1. Government of Ontario Statutes of Legislations and Regulations, Consolidated Hearings Act, Revised Statutes of Ontario, 1990, Chapter C.29

2. Government of Ontario Statutes of Legislations and Regulations, Conservation Authorities Act, Revised Statutes of Ontario, 1990, Chapter C.27

3. Government of Ontario Statutes of Legislations and Regulations, Environmental Assessment Act, Revised Statutes of Ontario, 1990, Chapter E.18

4. Government of Ontario Statutes of Legislations and Regulations, Environmental Protection Act, Revised Statutes of Ontario, 1990, Chapter E.19

5. Government of Ontario Statutes of Legislations and Regulations, Municipal Act, Revised Statutes of Ontario, 1990, Chapter M.45

6. Government of Ontario Statutes of Legislations and Regulations, Occupational Health and Safety Act, Revised Statutes of Ontario, 1990, Chapter O.1

7. Government of Ontario Statutes of Legislations and Regulations, Ontario Water Resources Act, Revised Statutes of Ontario, 1990, Chapter O.40

8. Government of Ontario Statutes of Legislations and Regulations, Pesticides Act, Revised Statutes of Ontario, 1990, Chapter P.11

B. Relevant Government Regulations

9. Government of Ontario Statutes of Legislations and Regulations, Regulation 347, Revised Regulations of Ontario, 1990 as amended to Ontario Reg 555/92.

10. Government of Ontario Statutes of Legislations and Regulations, Regulation 308, Revised Regulations of Ontario, 1980 as amended to Ontario Reg 90/90, October, 1990 issue.

11. Government of Ontario Statutes of Legislations and Regulations, Ontario Regulation 695/88 as amended to Ontario Regulation 533/89, Effluent Monitoring Regulation - General.

12. Government of Ontario Statutes of Legislations and Regulations, Regulations for Construction Projects, RSO 1980, Chapter 321 as amended to Ontario Regulation 213/91

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